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A FUEL AND BOILER EXHIBIT.

A very interesting exhibit at the St. Louis Exposition will be that in the Steam, Gas and Fuels Building. Here will be shown in operation all the machinery employed in connection with a modern boiler house. Coal will be brought in automatic self-cleaning cars to the building, where it will be taken in hand by the various types of coal-handling machinery. The boilers will burn coal, briquettes and oil, and they will be fitted for mechanical and hand stoking. The types shown will include foreign as well as American makes, and they will be fitted with all appliances. Unquestionably the exhibit made here will be a revelation to by far the greater number of visitors to the boiler houses, who probably imagine a boiler room to be a room containing a number of round kettles with fires under them, instead of what it actually is to-day—one of the most completely equipped shops for handling special materials; in this case, coal and water.

THE MEETING OF THE BRITISH ASSOCIATION.

In this issue we publish a report of the annual meeting of the British Association for the Advancement of Science. This meeting, which was held at Southport, was well attended, those taking part in the proceedings including some of the most distinguished men in the scientific world. The work done by the association covers all branches of theoretical and applied science. A number of very interesting papers on electrical topics were presented, several of which appear in this issue and others will be published shortly.

ELECTRICALLY OPERATED MINE HOISTS.

The electric motor is surely and steadily making its way in mining work. It has been used for a number of years for mine lighting and haulage and for operating coal-cutting machinery and drills. More recently, it has been applied with marked success for pumping and draining. But this application of the electric motor to mine hoisting has been retarded by a natural conservatism on the part of mining engineers. In work of this kind, safety and surety of control above all are the points to be considered. Mining engineers have been familiar with the performance of steam-hoisting apparatus, and have, perhaps naturally, felt some hesitation in changing to a new motive power however well this might be recommended. However, within the last year or so, the advantages offered by an electric drive have led a number of manufacturing concerns to turn their attention to this particular class of work with the result that they are now making hoisting machinery, electrically driven, which seems to offer all the surety of a steam-driven plant, and in addition is more economical and more easily controlled. It would seem from this that it should not be long before there will be a goodly number of mining plants operated entirely by electric power.

THE ENERGY OF ELECTROLYSIS.

An objection which is frequently raised against the dissociation theory of solution is that it seems paradoxical if the energy transfer during electrolysis be considered. The misunderstanding doubtless is caused by the usual method of describing the action which is assumed to take place during electrolytic decomposition. It is generally stated that the free ions carrying their respective charges move to the cathode and anode, there give up their charges to the electrodes, and become free atoms.

Mechanical Analogy Carried Too Far.

As has been clearly pointed out, the dissociation theory is nothing more than a model which is intended to give an idea of

the mechanics of electrolytic action, and the difficulty encountered when considering the energy changes arise from adhering too strictly to the mechanical analogue. We are accustomed to speak of an electric current as flowing in a certain direction. We think of the positive ions as carrying a positively charged electron, and we think of positive electricity as flowing out of the electrolytic cell from the cathode. Naturally, one at first is led to speak of the positive ion as giving up its positive charge to the cathode, so that there apparently should be a transfer of energy from the ion to the cathode. This, of course, we know does not represent the actual condition.

Flow of Energy Not Necessarily from Positive Electrode to Negative.

This difficulty disappears, however, if we remember that when we say that a current is flowing in a certain direction we are only using a conventional expression. We think of energy being transferred by a flow of positive electricity in one direction through the circuit, but we might just as well think of an equal flow of negative electricity in the opposite direction. The result in any case would be the same. Indeed, at the present time one is inclined to the opinion that the latter statement more nearly represents our knowledge, because, while we are more or less familiar with the negative electron, the positive electron has not yet been discovered.

One Way of Describing the Action During Electrolysis.

Recognizing, then, that we must not interpret too literally the statement made to describe electrolytic action, the apparent paradox of the dissociation theory disappears. The reactions may be described in this way: In an electrolyte we have the two ions carrying the one a negative and the other a positive charge. Under the influence of the difference of electric potential existing between electrodes the positively charged ions move toward the cathode; the negatively charged, toward the anode. Arriving at the two electrodes, the positively charged ion receives an equal but opposite charge of negative electricity. It then becomes neutral, and while it has apparently given up its charge it has received energy. Further, the cathode has given up a charge of negative electricity. It therefore has apparently received a positive charge, although we know it has given up energy to the solution. At the other end of the cell the opposite reaction is taking place: The negatively charged ions move to the anode and there receive charges of positive electricity which neutralize the negative charges and supply them with the energy required to convert them into atoms. The anode has then given up a positive charge of electricity to the solution and transferred energy to it at the same time. So far as the external circuits is concerned, this is not affected by this method of describing the reaction, because the same result is brought about as described above, whether we assume positive electricity to flow in one direction or negative to flow in the other. Indeed, in this case we assume that negative electricity flows from the source of supply to the cathode, and positive from the same source to the anode. The electrical displacement is completed by the motion in opposite directions of oppositely charged ions in the solution. In fact, a static condenser, as usually described, gives us a very satisfactory model for an electrolytic cell, except of course the action is not continuous in the condenser.

BEST CONDITIONS FOR REFINING COPPER.

A paper upon copper refining, presented by Dr. Wilder D. Bancroft at the recent meeting of the American Electrochemical Society, at Niagara Falls, is an illustration of what can be accomplished in the laboratories of our technical schools. The object of the work described in this paper was to determine the most economical conditions for refining copper, and with this end in view a series of tests was made to ascertain what conditions of current density and temperature would give a pure deposit of copper with the least cost. These tests having been run, it was possible to plot curves showing the variation in cost with changes in current density or temperature, and from these curves the conditions for minimum cost are at once seen.

Valuable Deductions in the Paper.

A criticism which was made of this paper was that it did not consider the cost of labor and of other factors which depend largely upon local conditions, and that these conditions might, and in many cases would, change entirely the conclusions reached in the paper. On the other hand, although those factors which were not considered in the paper, and which vary with the locality, may be the controlling ones, this in no way detracts from the value of the paper. Dr. Bancroft's results are given in such a way that each refiner can apply the necessary corrections and determine for himself the best conditions for his plant; while had such factors as the price of labor been considered in preparing the paper, the results would have been applicable only to the particular case considered, and not been of general application. Dr. Bancroft's paper, besides being of value in itself, should stimulate our electrochemical laboratories to take up in the same way other processes, many of which to-day are conducted by rule-of-thumb methods.

JUDICIAL PROTECTION AGAINST LEGISLATIVE REGULATION OF RATES FOR PUBLIC SERVICE.

Under the Fourteenth Amendment the right to reasonable compensation for property used in public service is guaranteed by the Federal Constitution.

Question of the Validity of State Regulation.

The question of the validity of state regulation of rates may thus be raised in the Federal courts when this right is claimed to be violated. The degree of judicial protection against rate regulation is thus to be found, as a last resort, in the decisions of the Supreme Court of the United States.

State Regulation Upheld by Courts.

That the several states have power to fix rates for public service has been established by an unbroken line of Supreme Court decisions from Munn *vs.* Illinois, the first of the Granger cases (94 U. S., 113), decided in 1876, down to Smyth *vs.* Ames (169 U. S., 466), decided in 1898. The power of the Supreme Court under the Fourteenth Amendment is therefore asserted not to prevent or necessarily annul state regulation of rates, but to keep such regulation within reasonable limits. This position of the Court was clearly stated during the opinion

in Chicago and Grand Trunk Railway Company *vs.* Wellman (143 U. S., 339), where it was said that:

"The legislature has power to fix rates, and the extent of judicial interference is protection against unreasonable rates."

Capital Entitled to Earn More than Going Rate of Interest.

Rates to be reasonable should yield a net return somewhat greater, as a rule, than the prevailing rate of interest on money loaned with good security. In other words, capital used in a public service is entitled to earn, under ordinary circumstances, the going rate of interest plus a greater or less percentage as compensation for the risks of a public calling, above all expenses of operation.

Effect of Risk on Legitimate Earnings.

If, for example, the degree of risk in a certain line of public service is such that a moderate issue of its bonds bearing interest at five per cent can be sold at par, then the capital invested in capital stock for that service may be entitled to earn eight per cent annually, more or less, after operating expenses and interest on the bonds are paid. Obviously, the greater the risks in a given public calling, the higher must be the interest on its bonds to ensure their sale at par, and the higher must be the rate of dividends on stocks to cover the element of risk.

Supreme Court Decisions.

This statement of the law is a little more definite than any on the point in decisions of the Supreme Court, but it is believed to embody the underlying principle of several of its later opinions. In Covington and Lexington Turnpike Road Company *vs.* Sandford (164 U. S., 578), it was decided that an act of the Kentucky Legislature, which reduced the rates of toll on the turnpike to a point where no dividends could be earned on the investment, was unconstitutional. The Turnpike company in this case was earning an annual dividend of four per cent on its capital stock before the legislation in question was enacted. As this legislation destroyed the prospect of any dividend whatever, the opinion in the case is only to the point that the company had a right to earn something above operating expenses, since this was all that it was necessary for the Court to decide. There is nothing in the opinion, however, to indicate that the Court thought that a dividend of four per cent was too high. A significant dictum in the case states that a corporation operating a public highway has a right to demand of a legislature, at the utmost, "that it receive what, under all the circumstances, is such compensation for the use of its property as will be just both to it and to the public."

The Ames Case.

Smyth *vs.* Ames (169 U. S., 466), decided in 1898, gives some additional light on the percentage of dividends that a public service company has a right to earn in spite of legislative regulation, but is far from conclusive on this point. A law of Nebraska fixing freight rates on railways was held to be invalid in this case, because it appeared that the enforcement of these rates would reduce the gross earnings of some of the roads affected to amounts that would not exceed operating expenses, and would permit only a small dividend on others. On several of the railways in question it was shown that the rates named by the legislature would permit some net earnings, amounting to as much as ten per cent yearly on the value of the road in at least one instance. Inasmuch as the Nebraska act was held to be invalid in relation to all of the railways concerned, the Court evidently held that ten per cent on the value of a railway is not as much as it has a constitutional right to earn above its operating expenses.

Company Entitled to a Fair Return.

The mere fact that rates prescribed by a legislature will permit nothing above operating expenses to be earned on some railways, does not render these rates invalid as to other railways where they permit adequate earnings. This proposition agrees with the well established rule that a legislative act is invalid only so far as it conflicts with the Constitution, and is supported by distinct dicta in the Sandford case already cited. No argument is necessary, however, to establish the conclusion that the earnings of each of the Nebraska railways under the rates fixed by the legislature would have been less than it was entitled to earn under the Constitution, for the Court said on this point: "in the exceptional cases above stated, when two of the companies would have earned something above operating expenses, in particular years, the receipts or gains, above operating expenses, would have been too small to affect the general conclusion that the act, if enforced, would have deprived each of the railroad companies involved in these suits of the just compensation secured to them by the Constitution."

As a general rule the opinion lays down that: "What the company is entitled to ask is a fair return upon the value of that which it employs for the public convenience."

In this case "a fair return" meant something more than five per cent per annum above operating expenses on one or more of the railways, but just how much more is not stated.

A Company Has a Right to Charge Profitable Rates.

On the authority of the Supreme Court, then, as laid down in the Sandford case and the Ames case, the rule is that a company engaged in a public service has a constitutional right to charge rates that will yield "something" above operating expenses, and apparently, also, that this something should be more than five per cent on the value of its property. The lower limit for net earnings of a public service is thus set; what the higher limit is, the Supreme Court has not yet decided.

From the standpoint of reason, however, it seems clear that a public service should ordinarily earn something to compensate stockholders for the risks of the business, over and above all expenses of operation as above stated.

The Two Most Definite Court Statements.

The Sandford case decided in 1896 and the Ames case decided in 1898, were both concurred in by the entire Court, and are believed to afford the most definite statements that the Court has thus far made touching the income that reasonable rates must yield. There are dicta in both of these cases to the effect that circumstances might exist under which a corporation engaged in public service would not be entitled to earn anything above operating expenses. What these circumstances are is not clearly indicated, however, and it seems certain that they must be of a very exceptional character.

A number of cases involving the reasonableness of rates and the percentage of net earnings in public callings have reached the Circuit Courts of the United States, and these Courts have carried the protection of property in such callings quite as far as the Supreme Court.

LIGHTNING ARRESTERS ON TRANSMISSION LINES.

BY ALTON D. ADAMS.

Long electrical transmission without protection from lightning would be very unreliable. A wire scores of miles long and with elevations in its different parts that sometimes vary several thousand feet may act as both a conductor and condenser of atmospheric electricity. If a direct stroke of lightning, that is an electric current passing between clouds and the earth, chooses the line for its path the line acts as a conductor. So again when there is a lightning discharge either between two clouds or between clouds and the earth, near to but not by way of the transmission line, the lightning discharge may induce a very high voltage in the line wires acting as secondary conductors. When there is no passage of electric current between clouds and the earth or between cloud and cloud the movements of charged clouds may induce static charges in line wires like the charges of a condenser. If the pressure of this static charge becomes great enough it will find its way to earth at some point where the insulation of the line or the apparatus to which it is connected is low. The danger from either form of atmospheric electricity is thus that in its passage from the line to earth the insulation of the line or of some connected apparatus will be destroyed.

Dangers of this sort are of a very real and present character. The annual reports of the United States Weather Bureau show a maximum number of about seventy thunder-storm days per year in Florida and an average of about thirty such days per year for the entire country. Some mountainous states like the Carolinas and Colorado are particularly subject to frequent thunder-storms. Times of thunder-storm are not the only periods during which the effects of atmospheric electricity are to be feared in transmission systems. In many parts of the country and especially where long transmission lines vary greatly in altitude during their course the wires often become charged at high pressure under a clear sky, and this pressure is sometimes great enough to do serious personal injury and to pierce the insulation of generators and transformers. According to a report of a plant at Telluride, Col., where a line ten miles long varied between 8,000 and 12,000 feet in elevation, forty fuses used with one type of lightning arrester were on a certain occasion burned out within an hour and five armature coils were destroyed in a single storm (XI, A. I. E. E., 346, 350). In this plant the insulation of the apparatus became perforated by lightning in many places so as to cause frequent grounds and short-circuits. The transmission line between Niagara Falls and Buffalo was struck five times by lightning during a single thunder-storm and five poles with their cross-arms were destroyed (XVIII, A. I. E. E., 537). It is not unusual to see the lightning arresters at a station connected to a long transmission line flash scores of times during a thunder-storm, often with loud reports, and for the flashing at the arresters to be continuous for several minutes at a time.

Lightning arresters are wrongfully named, for their true purpose is not to arrest or stop lightning, but to offer it so easy a path to ground that it will not force its way through the insulation of the line or of machinery connected to the system. The requirements of a lightning arrester are in a degree conflicting because the resistance of the path it offers must be relatively low as to discharges of atmospheric electricity to earth but relatively high as to any flow of current between the transmission lines. In other words the insulation of the line conductors must be maintained at a high standard in spite of the connection of lightning arresters between each conductor and the earth, but the resistance of the arrester must not be so high that lightning will pierce the insulation of the line or machinery at some other point. When a lightning discharge takes place through an arrester the resistance which the arrester offers to a flow of current is for the moment greatly reduced by the arcs which the lightning sets up in jumping the air-gaps of the arrester. Each wire of a transmission circuit must be connected alike to arresters and the paths of low resistance through arcs in these arresters to the earth would obviously short-circuit the connected generators unless some construction were adopted to prevent this result. In some early types of lightning arresters magnetic or mechanical devices were resorted to in order to break arcs formed by the discharge of lightning. The general objection to this class of arresters is that a serious short-circuit may be formed before the arc formed by the lightning can be broken by any mechanical movement.

The type of lightning arrester now in common use on transmission lines with alternating current includes a row of short, parallel, brass cylinders mounted in a row in a porcelain block and with air-gaps of one-thirty-second to one-sixteenth of an inch between their parallel sides. The cylinder at one end of the row is connected to a line wire and the cylinder at the other end to the earth, when a 2,000 or 2,500-volt circuit is to be protected. For higher voltages there are a number of these single arresters connected in series with each other and then the free ends of the series to a line wire and to the earth, respectively. Thus, for a 10,000-volt line four or, better, five single arresters are connected in series to form a composite arrester for each line conductor. For any given line voltage the number of single arresters going to make up the composite arrester for each line conductor should be so chosen that the regular working voltage will not jump the series of air-gaps between the little brass cylinders, but yet so that any large rise of voltage will be sufficient to force sparks across these gaps. A variation of this practice by one large manufacturing company is to mount the group of single arresters on a marble board in series with each other and with an adjustable air-gap. This gap is intended to be so adjusted that any large increase of voltage on the lines will be relieved by a spark discharge. An arrester made up entirely of the brass cylinders and air-gaps has the serious disadvantage that an arc once started between all the cylinders by a lightning discharge so lowers the resistance between each line wire and the earth that the generating equipment is short-circuited and the arcs do not cease with the escape of atmospheric electricity. To avoid this difficulty it is the practice to connect a conductor of rather large ohmic resistance in series with the brass cylinders and air-gaps of lightning arresters. This resistance should be non-inductive so as not to offer a serious obstacle to lightning discharge, and its resistance should be great enough to prevent a flow of current from the generators that will be large enough to maintain the arcs started in the arrester by the lightning discharge. Accurate data is lacking as to the amount of this resistance that should be employed with arresters for any given voltage. As a rough, approximate rule it may be said that in some cases good results will be obtained with a resistance in ohms in series with a group of lightning arresters that represents one per cent of the numerical value of the line voltage. That is, for a 10,000-volt line the group of arresters for each wire may be connected to earth through a resistance of, say, 100 ohms, so that if the generator current follows the arc of a

lightning discharge through the arresters it must pass through a fixed resistance of 200 ohms in going from one line wire to another. It should be noted that this rule is given merely as an illustration of the resistance that will work well in some cases and should not be taken to have any general application. If the resistance connected in series with lightning arresters is high the tendency is a little greater for lightning to pass by the arresters and go to earth at some point in the apparatus where the insulation is low. If only a small resistance is employed to connect lightning arresters with the earth the danger is that arcs formed by lightning discharges will be followed and maintained by the dynamo currents. In one make of lightning arrester the row of little brass cylinders is connected at each end to a carbon rod which forms a resistance for the purpose just mentioned. Two of these carbon rods are contained in each arrester for 2,000 or 2,500 volts, and the resistance of each rod may be anywhere from several score to several hundred ohms as desired. This form of arrester may be connected directly from line to earth without the intervention of any outside resistance since the carbon rods may easily be given all the resistance that is desirable.

One of the most important features in the erection of a lightning arrester is its connection to earth. If this connection is poor it may render the arrester useless so far as protection from lightning is concerned. It need hardly be said that ground connections formed by driving long iron spikes into the walls of buildings or into dry earth are of no value so far as protection from lightning is concerned. A good ground connection for lightning arresters may be formed with a copper or galvanized iron plate, which need not be over one-sixteenth of an inch thick, but should have an area of, sav. ten to twenty square feet. This plate may be conveniently made up into the form of a cylinder and should have a number of half-inch holes punched in a row down one side into which one or more copper wires with an aggregate area equal to that of a No. 4 or No. 2 wire, B. & S. gauge, should be threaded and then soldered. This plate or cylinder should be placed deep enough in the ground to ensure that the earth about it will be constantly moist, and the connected copper wire should extend to the lightning arresters. It is a good plan to surround this cylinder with a layer of coke or charcoal.

A good earth connection for lightning arresters may be made through large water pipes, but to do this it is not enough to simply wrap the wire from the lightning arresters about the pipe. A suitable contact with such a pipe may be made by tapping one or two large bolts into it and then soldering the wire from lightning arresters into holes drilled in the heads of these bolts. A metal plate laid in the bed of a stream makes a good ground.

With some of the older types of lightning arresters it was the custom to insert a fuse between the line wire and the ground, but this practice defeats the purpose for which the arrester is erected because the fuse melts and leaves the arrester disconnected and the circuit unprotected with the first lightning discharge. The modern arresters for alternating-current circuits are made up of a series of metal cylinders and short air-gaps and are connected solidly without fuse between line and earth.

It was once the practice to locate lightning arresters almost entirely in the stations, but this has been modified by experience and consideration of the fact that as the line acts as a collector of atmospheric electricity, paths for its escape should be provided along the line. Consideration fails to reveal any good reason why lightning that reaches a transmission line some miles from a station should be forced to travel to the station, where it may do great damage before it finds an easy path to earth. It is, therefore, present practice to connect lightning arresters to each wire at intervals along the line as well as at stations and substations. The main purpose of arresters is to offer so easy a path to earth that lightning discharges along the lines will not flow to points of low insulation in generators, transformers or even the line itself. Practice is far from uniform as to the distance between lightning arresters on transmisssion lines, the distances varying from less than one to a large number of miles apart. In general the lines should be provided with lightning arresters at least where they run over hilltops and at any points where lightning strokes are unusually frequent. Where a long overhead line joins an underground cable arresters should always be connected and the same is true as to transformers located on the transmission line. The multiplication of arresters along pole lines should be avoided as far as is consistent with suitable protection, because every bank of arresters may develop a permanent ground or short-circuit, unless frequently inspected and kept clean and in good condition.

Arresters, besides those connected along the lines, should be located either in or just outside of stations and substations in every instance. If the buildings are of wood the arresters had better be outside in weather-proof cases, but in brick or stone buildings the arresters may be properly located near an interior wall and well removed from all the other station equipment. Transmission lines, on entering a station or substation, should pass to the arresters before connecting with any of the operating machinery.

To increase the degree of protection afforded by lightning arresters choke-coils are frequently used with them. A choke-coil for this purpose usually consists of a flat coil of copper wire or strip containing twenty to thirty or more turns and mounted with terminals in a wooden frame. This coil is connected in series with the line wire between the point where the top for the lightning arrester is made and the station apparatus. Lightning discharges are known to be of a highly ocsillatory character, their frequency being much greater than that of the alternating currents developed in transmission systems. The self-induction of a lightning discharge in passing through one of these choke-coils is great and the consequent tendency is to keep the discharge from passing through the choke-coil and into the station apparatus and thus to force the discharge to pass to earth through the lightning arrester. The alternating current employed in transmission has such a comparatively low frequency that its self-induction in a choke-coil is small. Increased protection against lightning is given by the connection of several groups of lightning arresters one after another on the same line wire at an electric station. This gives any lightning discharge that may come along the wire several paths to earth through the different groups of arresters and a discharge that passes the first group will probably go to earth over the second or third group. In some cases a choke-coil is connected into a line wire between each two groups of lightning arresters as well as between the station apparatus and the group of arresters nearest thereto.

An electric transmission plant at Telluride, Col., where thunder-storms are very frequent and severe, was equipped with arresters and choke-coils of the type described and the results were carefully noted (XI, A. I. E. E., 346). A small house for arresters and choke-coils was built close to the generating station of this system and they were mounted

therein on wooden frames. Four choke-coils were connected in series with each line wire, and between these choke-coils three lightning arresters were connected, while a fourth arrester was connected to the line before it reached any of the choke-coils. These arresters were watched during an entire lightning season to see which bank of arresters on each wire discharged the most lightning to earth. It was found that, beginning on the side that the line came to the series of arresters, the first bank of arresters was traversed by only a few discharges of lightning, the second bank by more discharges than any other, the third bank by quite a large number of discharges, and the fourth bank seldom showed any sign of lightning discharge. Over the second bank of arresters the lightning discharges would often follow each other with great rapidity and loud noise. The obvious conclusion from these observations seems to be that three or four banks of lightning arresters connected in succession on a line at a station together with choke-coils form a much better protection from lightning than a single bank. At the plant in question, that of the San Maguel Consolidated Gold Mining Company, the entire lightning season after the erection of the arresters in question was passed without damage by lightning to any of the equipment. It would be very interesting to know what results would have been attained at this plant if the choke-coils had been omitted, but the conditions do not seem to have been varied in that way. During the two lightning seasons previous to that just named the damage by lightning to the generating machinery at the plant had been frequent and extensive.

A good illustration of the high degree of security against lightning discharges that may be obtained with lightning arresters and choke-coils exists at the Niagara Falls plants and the terminal house in Buffalo, where the step-up and step-down transformers have never been damaged by lightning though the transmission line has been struck repeatedly and poles and cross-arms shattered (XVIII, A. I. E. E., 527). This example bears out the general experience that lightning arresters, though not an absolute protection, afford a high degree of security to the apparatus at electric stations.

Lightning arresters are in some cases connected across high-voltage circuits from wire to wire so that the full line pressure tends to force a current across the air-gaps. The object of this practice is to guard against excessive voltages on the circuit such as might be due to resonance. In such a case, as in that where arresters are connected from line wire to earth as a protection against lightning, the number of air-gaps should be such that the normal line voltage will not force sparks across the air-gaps and thus start arcs between the cylinders.

The number and total length of air-gaps in a bank of arresters necessary to prevent the formation of arcs by the regular line voltage depends on a number of factors besides the amount of that voltage.

According to the report of the Committee on Standardization of the American Institute of Electrical Engineers the sparking distances in air between opposed sharp needle points for various effective sinusoidal voltages are as follows (XIX, A. I. E. E., 721):

Kilovolt Square Root of Mean Square.	Inches Sparking Distance.
5	0.225
10	0.47
15	0.725
20	1.0
25	1.3
30	1.625
35	2 0
40	2 45
45	2.95
50	3.55
60	4.65
70	5.85
80	7.1
90	8.35
100	9.6
110	10.75
120	11.85
130	12.95
140	13.95
150	15.0

It may be noted at once from this table that the sparking distance between the needle points increases much faster than the voltage between them. Thus, 20,000 volts will jump an air-gap of only an inch between the points, but seven times this pressure or 140,000 volts will force a spark across an air-gap of 13.95 inches. Two cylinders or other blunt bodies show smaller sparking distances between them at a given voltage than do two needle points, but when a number of cylinders are placed in a row with several short air-gaps between them, the aggregate length of these gaps that will just prevent the passage of sparks at a given voltage may be materially greater or less than the sparking distance of that voltage between needle points. It has been found by experiment that the numbers of three and one-thirty-second inch spark-gaps between cylinders of non-arcing alloy necessary to prevent the passage of sparks with the voltages named and a sine wave of electromotive force are as follows (XIX, A. I. E. E., 668):

Number of 1/32-Inch Air-Gaps in Series.	Normal Voltage Withheld.	Number of 3/32-Inch Air-Gaps in Series.	Normal Voltage Withheld.
5	6,800	50	22,600
10	10,000	55	23,900
15	12,500	60	25,000
20	14,500	65	26,000
25	16,400	70	27,000
30	18,200	75	28,000
35	19,300	80	29,000
40	20,500	..	....
45	21,700	..	....

According to this data only ten air-gaps of one-thirty-second of an inch each and 0.3125 inch combined length are required between cylinders to prevent a discharge at 10,000 volts, though opposed needle points may be 0.47 inch apart when a spark is obtained with this voltage. On the other hand, eighty air-gaps of one-thirty-second of an inch each between cylinders of non-arcing metal, or a total gap of 2.5 inches, are necessary to prevent a discharge at 29,000 volts, though 30,000 volts can force a spark across a single gap of only 1.625 inches between opposed needle points.

Under the conditions that existed in the test just recorded the pressure at which the aggregate length of one-thirty-second of an inch air-gaps that just prevents a discharge equals the single sparking distance between needle points seems to be about 18,000 volts.

The object of dividing the total air-gap in a lightning arrester for lines that carry alternating current up into a number of short gaps is to prevent the continuance of an arc by the regular generator or line current after the arc has been started by a lightning discharge. As soon as an electric spark leaps through air from metal to metal, a path of low electrical resistance is formed by the intensely heated air and metallic vapor. If the arc thus formed is, say, two inches long it will cool a certain amount as the passing current grows small and drops to zero. If, however, this total arc of two inches is divided into sixty-four parts by pieces of metal, the process of cooling as the current decreases will go on much more rapidly than with the single arc of two inches because of the great conducting power of the pieces of metal. As an alternating current comes to zero twice in each period, the many short arcs formed in an arrester by a lightning discharge are so far cooled during the small values of the following line current that the resistance rises to a point where the regular line voltage can not continue

to maintain them, if the arrester is properly designed for the system to which it is connected. In this way the many gap arrester destroys the many small arcs started by lightning discharges that would continue and short-circuit the line if they were combined into a single long arc.

When an electric arc passes between certain metals like iron and copper a small bead is raised on their surfaces. If these metals were used for the cylinders of arresters the beads on their surfaces would quickly bridge the short air-gaps. Certain other metals like zinc, bismuth and antimony are pitted by the passage of arcs between their surfaces. By suitable mixture of metals from these two classes an alloy is obtained for the cylinders of lightning arresters that pits only slightly and is thus but little injured by lightning discharges. After long use and many discharges an arrester of the class here considered gradually loses its power to destroy electric arcs. This may be due to the burning out of the zinc and leaving a surface of copper on the cylinders.

Aside from the structure of an arrester and the normal voltage of the circuit to which it is connected, its power to destroy arcs set up by lightning discharges depends much on the capacity of the connected generators to deliver current on a short-circuit through the gaps, and upon the inductance of the circuit. The greater the capacity of the generators connected to a system the more trying are the conditions under which arresters must break an arc because the current to be broken is greater. So, too, an increase of inductance in a circuit adds to the work of an arrester in breaking an arc.

An arc started by lightning discharge at that period of a voltage phase when it is at or near zero is easily destroyed by the arrester, but an arc started at the instant when the regular line voltage has its maximum value is much harder to break because of the greater amount of heat generated by the greater current sent through the arrester. For this reason the arcs at arresters will hold on longer in some cases than in others, according to the portion of the voltage phase in which they are started by the lightning discharge. Lightning discharges, of course, may occur at any phase of the line voltage and for this reason a number of discharges must take place before it can be certain from observation that a particular arrester will always break the resulting arc. Between twenty-five and sixty cycles per second there is a small difference in favor of the latter in the power of a given arrester to break an arc, due probably to the fact that more heat in the arcs is developed per phase with the lower than with the higher frequency.

It will now be seen that while increase of the regular line voltage requires a lengthening of the aggregate air-gap in lightning arresters to prevent the formation of arcs by this voltage alone, the increase of generating capacity requires more subdivisions of the total air-gap in order that the arcs maintained by the larger currents may be cooled with sufficient rapidity. These two requirements are to some extent conflicting, because the subdivision of the total air-gap renders it less effective to prevent discharges due to the normal line voltage, as has already been shown. The result is that the more an air-gap is subdivided in order to cool and destroy arcs that have been started by lightning, the longer must be the aggregate air-gap in order to prevent the development of arcs directly by the normal line voltage.

Furthermore, the practical limit of subdivision of the air-gap is soon reached because of the difficulty of keeping very short gaps clean and of nearly constant length. As a resistance in series with an arrester cuts down the generator current that can follow a lightning discharge, such a resistance also decreases the number of air-gaps necessary to give an arrester power to destroy arcs on a particular circuit.

The increase of resistance in series with a lightning arrester as well as the increase in the aggregate length of its air-gaps subject the insulation of connected apparatus to greater strains at times of lightning discharge. On systems of large capacity the number and aggregate length of air-gaps in arresters necessary to destroy arcs must be greater than the number or length of these air-gaps necessary to prevent the development of arcs by the normal line voltage, unless a relatively large resistance is connected in series with each arrester. To reduce the strains produced on the insulation of line and connected apparatus under these conditions by lightning discharges a resistance is connected in shunt with a part of the air-gaps in one make of lightning arrester. The net advantage claimed for this type of arrester is that a lower resistance may be used in series with all the air-gaps than would otherwise be necessary. One-half of the total number of air-gaps in this arrester are shunted by the shunt resistance and the series and shunt resistance are in series with each other. Only the series air-gaps or those that are not shunted must be jumped in the first instance by a lightning discharge which thus passes to earth through these air-gaps and the shunt and series resistances in series. An arc is next started in the shunted air-gaps and this arc is in turn destroyed because the shunt weakens the current in these gaps. This throws the entire current of the arc through the series air-gaps and the shunt and series resistances all in series with each other. As the shunt resistance is comparatively large the current maintaining the arc in the series air-gaps is next so reduced that this arc is broken. Taking the claims of its makers just as they stand the advantages of the shunted air-gaps are not very clear. The series air-gaps alone must evidently be such that the normal line voltage will not start an arc over them, and these same series gaps must be able to break the arcs of line current flowing through them and the shunt and series resistances all in series. Evidently the greatest strain on the insulation of the line and apparatus occurs at the instant when the lightning discharge takes place through the series gaps and the shunt and series resistances all in series with each other.

Why develop subsequent arcs in the shunted air-gaps? Why not throw the shunted air-gaps away and combine the shunt and series resistances?

Production of Zinc in 1902.

In his report to the United States Geological Survey, now in press, Mr. Charles Kirchhoff says that the production of zinc in 1902 was greater than ever before, reaching a total of 156,927 short tons. The production in 1901 was 140,822 short tons, and in 1900 it was 123,886 tons. Of the output for 1902, the eastern and southern states contributed 12,180 short tons, Illinois, including Indiana, 47,096 short tons, Kansas, 86,564 tons, and Missouri, 11,087 tons. The statistics of the production of spelter include always the metal produced by several works that treat drosses exclusively. In 1902 these works made 2,716 short tons, and in 1902 they produced 2,675 short tons.

The consumption of spelter in 1902 was heavy, the principal industries in which it is a factor being extremely busy. The apparent home consumption in 1902 was 152,682 short tons as against 141,697 short tons in 1901 and 99,399 tons in 1900.

Prices were quite satisfactory during the year, and the demand was such that no ore was exported.

Colorado has become an important

producer of zinc ore, the output for the year 1902 being placed at 26,241 short tons, valued at $2,544,993. The production of zinc ore in New Jersey in 1902 was 209,386 short tons, as against 191,221 short tons in 1901.

The total value of the zinc imported and entered for consumption in the United States in 1902 was $85,882, as against $76,059 in 1901 and $128,090 in 1900. The exports of zinc in 1902 were valued at $1,863,858, as against $1,538,636 in 1901 and $3,450,644 in 1900; and the exports of zinc ore in 1902 were valued at $1,449,104, as against $1,167,684 in 1901 and $1,133,663 in 1900. The world's production of zinc and the United States' percentage of the world's production, respectively, in 1902 are as follows: Total production, 538,784 long tons, percentage 26.0, as against 501,494 long tons, percentage 25.1 in 1901, and 470,937 long tons, percentage 23.5 in 1900.

The Permanency of the Atom.

Our chemical friends seem little inclined to abandon without a fight their belief in the immutability of the atom, a creed which for nearly a century has been shared by chemists and physicists alike. The modern chemist is, indeed, somewhat inclined to scientific Toryism; but this mental attitude is by no means uncommon among scientific men, as is well shown by the violent opposition which had to be conquered by the undulatory theory of light. It has, moreover, certain advantages. A new hypothesis must be compelled to prove that it has other claims to acceptance beyond its novelty and originality, and most useful work is done by the supporters of older theories in subjecting the newcomer to a searching criticism. Nevertheless, it would seem that the chemist has hitherto utterly failed to make any serious attack on the electrical theory of the atom, as now advanced by many physicists; an hypothesis which, as pointed out by Sir Oliver Lodge, involves the consequence that each and every atom is in a process of slow disintegration. Of course, the careful and painstaking work of the great chemists of last century only served to confirm the truth of Dalton's great generalization; but it has also to be remembered that for an equal period chemists had failed to detect in atmospheric air any trace of the new gases of the Argon group, and were indebted to a physicist for the hint which led to their discovery. Chemists claim that the known facts of radioactivity are capable of explanation on the lines of ordinary chemistry; but when their claims are more closely examined, it would seem that a truer statement of their case would be that some of the facts, in the absence of others, might be thus explained. Thus Dr. Lowry has suggested that the behavior of thorium X and thorium was precisely analogous to that of certain organic compounds, such as π bromo-nitro-camphor, which in its "normal" form is a neutral body and a dielectric, while in the "pseudo" form it is a strong acid and electrolyte. Either form is readily changeable into the other, the rate of change varying in the same manner as the radioactivity of thorium X and thorium. He entirely fails to take into account, however, the enormous amount of energy liberated in radioactivity; and as Professor Rutherford pointed out at the time, his hypothesis involved that of the possibility of perpetual motion. More recently Professor Meldola has suggested that radium, as we know it, is an endothermic compound of some unknown element with helium, and is not in itself an element at all. He points out that nitrogen, which to a certain degree resembles helium in its inertness, is a frequent constituent of endothermic compounds; and *a fortiori* suggests that a helium compound should on its decomposition liberate still greater energy. The objections to this hypothesis are several. In the first place it is difficult to believe that so endothermic a body as the proposed compound can be dissociated without an explosion. Secondly, the rate of the radium change seems nearly independent of the temperature, which is the case with no known chemical reaction; and, finally, the energy liberated is out of all proportion greater than that accompanying any known chemical change. Mr. C. D. Whetham states that the energy liberated by the dissociation of a gramme of radium is between 20,000 and 1,000,000 times as great as that set free in the formation of a gramme of water. Of course, the hypothesis that atoms consist merely of a constellation of negative and positive electrons is not yet fully proven, and it is certainly curious that no positive electron has yet been detected in the free state.—*Engineering* (*London*).

Automobile Club Trials.

The Automobile Club of Great Britain and Ireland has been conducting some practical trials of various makes of machines. The machines were tested first for brakes, dust and noise, and were then entered in a 1,000-mile endurance run. No electrically propelled car was entered.

Production of Lead in 1902.

Under the influence of a lower range of prices for lead, assisted, in the Rocky Mountain districts, by low returns for the accompanying silver, says Mr. Charles Kirchhoff, in his report to the United States Geological Survey on the production of lead in 1902, now in press, the lead-mining industry did not prosper in 1902 as much as other branches of metal mining. The principal cause was that in the previous years a very large stock of lead had accumulated. This was successfully worked off during 1902, which was a year of enormous consumption of all the metals. The stock of lead, which was 53,733 short tons at the beginning of the year, had been carried down to 11,595 short tons at its close. Under the circumstances the fact that the production was about as large in 1902 as it was in 1901 is encouraging; but there has been some shifting of the territorial source of production. Relatively, the Mississippi region has gained in importance, showing an increase in output at the expense of the Rocky Mountain districts, which declined in production.

The domestic production in 1902 was 270,000 short tons, as against 270,700 short tons in 1901, and 270,824 short tons in 1900. The production of refined lead in the United States in 1902, irrespective of the source from which it was drawn, amounted to 377,061 short tons, as against 381,688 short tons in 1901.

The apparent home consumption of lead in 1902 was 335,485 short tons, as against 274,020 short tons in 1901, and 269,302 short tons in 1900. The domestic consumption was greater than ever before in the history of the country.

The total value of lead imported and entered for consumption in this country in 1902 was $648,063, as against $364,459 in 1901, and $702,213 in 1900. The total value of the lead exports in 1902 was $696,010, as against $624,534 in 1901, and $459,571 in 1900.

In January, 1902, the American Smelting and Refining Company advanced the price of lead from four cents, which had been named in December, 1901, to 4.10 cents for moderate lots. At that price the metal was held during the remainder of the year.

Electric Signaling on Railways.

The Northeastern Railway, of England, has just installed the Crewe system of electric signaling in its freight yards at York.

THE STEAM, GAS AND FUELS BUILDING AT THE ST. LOUIS EXPOSITION.

TYPIFYING THE USE OF ALL MODERN FORMS OF FUEL AND FUEL ECONOMIZERS.

It is interesting to note the most recent ground plan issued by the Universal Exposition of 1904, and to compare it with the plans previously issued during the past two years. The claim has always been made that these ground plans have shown only such items as at the time of issue could be termed fixed facts, in other words, that they could be considered as plans showing the actual development. Comparison with previous issues seems to substantiate this claim and inspire confidence in the management which refrains from making statements until it is sure of making them good.

Over a year ago Mr. Moore, chief of the machinery department, claimed that the steam boiler, boiler appliance, gas producer and fuel-handling proposition would be adequately and creditably housed in a spacious building and that this building would be found in the centre of the grounds and at the intersection of the main thoroughfares connecting the northern and southern and the eastern and western sections of the exposition. To the outsider there seemed very little basis for this claim, but the physical evolution of the exposition appears to substantiate Mr. Moore's prediction. What at first was a boiler house about 100 by 75 is now the Steam, Gas and Fuels Building, a steel construction, fireproof structure, 326 by 300 feet. This building is over sixty per cent completed and the installation of boilers in it is already progressing. The structure is particularly light and airy and all the arrangements are to contribute to the programme for making this building attractive not only to the engineering fraternity but to the general public. It certainly is located at a point where, by the prominence of its location and the character of its surroundings, it can easily attract a full audience for its exhibitors.

The exhibits to be installed are intended to illustrate the most modern methods and economies in steam and gas generation and the handling and treatment of fuels. The illustration commences with the coal in fifty-ton, hopper bottom, self-cleaning, steel cars controlled and operated by the exposition. These cars bring the coal from the mine to the Steam, Gas and Fuels Building, there it is dumped and automatically conveyed to and from bunker and crusher, or either, and thence to the mechanical stokers, gas producers, and briquetting machines. Over 2,200 lineal feet of conveyor lines are required in this automatic coal-handling system. Bituminous coal, anthracite coal, briquettes and crude oil will all be availed of with the purpose of providing lines for comparison and to illustrate as fully as practicable the broad subject of the use of fuels for power purposes.

In both hand-firing and mechanical stokers particular attention is being paid to the avoidance of the smoke nuisance. The stoker builders are afforded an opportunity to substantiate their claims in this direction, for on installations of 1,500 horse-power or over a separate stack is to be furnished by the exposition for each installation and thus a line for practical demonstration and comparison is established. In hand-firing, briquettes will be largely availed of and the claim of the possibility of smokeless combustion from their use can be substantiated or refuted.

Boilers have been drawn from European as well as from American shops and particular attention is being paid to marine water-tube boilers. The standard marine types of boilers are less familiar than the standard stationary types to the average engineer, and it is believed that where economy of space is an essential they may demonstrate advantages. In any event opportunity for direct comparison between the various water-tube marine-type boilers operating side by side and under the same conditions will be interesting and instructive.

Different groups of boilers are to be operated at different pressures and practice from 125 pounds to 250 pounds illustrated.

Owing to the central location of the Steam, Gas and Fuels Building and in deference to the architectural harmony, it is impractical to establish natural draft boiler stacks, and, consequently, mechanical draft will be availed of. This affords the blower builders an opportunity to exploit their systems.

The water supply in St. Louis is not without features which are objectionable in boiler practice, and this condition is very generally being availed of by the builders of water-purifying apparatus to exploit the practical value of their systems.

The installation of a number of independent steam generating systems carries with it the possibility to illustrate a variety of accessory items, such as feed-water pumps, feed-water heaters, injectors, traps, valves, gauges and various steam specialties.

In gas producers the range is from a capacity to supply an engine of fifty horse-power to a capacity for a 3,000-horse-power unit or collection. The most notable producer units are as follows: one of 2,400-horse-power direct-suction system, from Julius Pintsch, of Berlin; one of 3,000-horse-power, Duff-Whitfield system, from W. F. Mason & Company, of Manchester, England, and one of 2,000-horse-power, from R. D. Wood & Company, Philadelphia. Both of the latter will avail of tanks or holders. A Thiessen gas scrubber built by the John Cockerill Society, of Seraing, Belgium, will be shown in operation. The installation of the latest gas producer serving the latest types of gas engines driving alternators and operating side by side on the same load with steam boilers at the one end and steam reciprocating and turbine engines on the other end will go far toward a determination of the claim by the gas engine advocates that the gas producer, gas engine proposition has in efficiency and first cost and operating expense great and universal advantages over the steam boiler, steam engine proposition.

The programme announced, and already so far carried into effect that we may reasonably look for its complete fulfilment, certainly demands consideration and no small amount of admiration. If Mr. Moore succeeds in doing what he has planned he will deserve great thanks from the engineering world, and in any event every assistance and encouragement should now be extended to him.

Purchasing a Play by Wireless Telegraphy.

On Thursday, October 1, a wireless telegram from Mr. Frank Curzon, the English theatrical manager who was at that time on board the St. Louis returning to England, was received by Mr. Charles B. Dillingham, the enterprising playwright and theatrical manager, while at the Garrick Theatre, making an offer for the English rights to "Her Own Way" in which Miss Maxine Elliott has been playing. Mr. Curzon saw the play on Tuesday night and just before sailing he telegraphed to Mr. Clyde Fitch, its talented author, asking for the English rights. Mr. Fitch answered with a wireless despatch, which reached the St. Louis off Nantucket, informing Mr. Curzon that Mr. Dillingham had already purchased the English rights. Mr. Curzon immediately sent a wireless despatch to Mr. Dillingham as mentioned above.

This incident shows how quickly an enterprising business man is to take advantage of the latest applications of electricity. Mr. Dillingham is now considering the offer which, had not wireless telegraphy service been available, would not have reached him until six days later.

Mountain Electric Road in Switzerland and the Sublin Hydraulic Plant.

By C. L. Durand.

WITHIN the last few years a great number of mountain railways have been installed along different points of the railroad lines in Switzerland, in order to afford an easy communication between the railway stations and the numerous villages or health resorts which are situated at the top of the mountains. This is of great benefit to these localities, as they can be reached in a small fraction of the time which is taken by the old horse conveyances winding around the mountain. An interesting example of a heavy grade electric line is afforded by the Bex-Gryon-Villars system, which commenced to operate a few years ago. This line has been equipped by the Compagnie de l'Industrie Electrique, of Geneva, on the Thury direct-current system. The current for the road is furnished by a large hydraulic plant in the vicinity.

The electric road is built in three distinct parts, as is required by the profile of the region. The line starts from the railroad station near the town of Bex and has a total length of eight miles. The first section from Bex to Bevieux passes through a level stretch and the trolley system is used with the ordinary track. From this point the road climbs up the mountain on a rack-and-pinion system to Gryon; from this point to the terminus at Villars the road is nearly level and the ordinary system is used. This railroad supplies a region which is much frequented by tourists; the town of Bex, in the Rhone valley, as a spring and autumn health resort, and Villars, on the summit of mountain as a summer station; the village of Gryon is likely to develop considerably as a health resort since the establishment of the road.

In order to operate the line under these conditions an electric locomotive and a motor car are employed. The motor car runs alone over the two level sections of the road at the top and bottom. On the rack-and-pinion section, in the middle, the electric locomotive is used to take the car up the grade. The trolley system is employed in all these cases.

Starting from the station of Bex, on the Jura-Simplon railroad, the motor car runs as far as Bevieux on a comparatively level grade. The rack-and-pinion system then commences to climb the side of the mountain, starting in front of the company's shops at Bevieux. This part of the line, which is 3.1 miles long, presents the most interesting feature on account of the steep grades and the road construction which includes a number of tunnels, cuts and embankment walls. The longest tunnel measures 650 feet and is built on a twenty per cent grade and a curve of 270 feet radius. After a number of other constructions the line passes over the road from Bex to Gryon on an iron bridge truss. After a long curve the line passes to the north and finally reaches the village of Gryon which is situated on the top of the mountain at an altitude of 3,700 feet. The rack-and-pinion road thus mounts a total height of 2,110 feet.

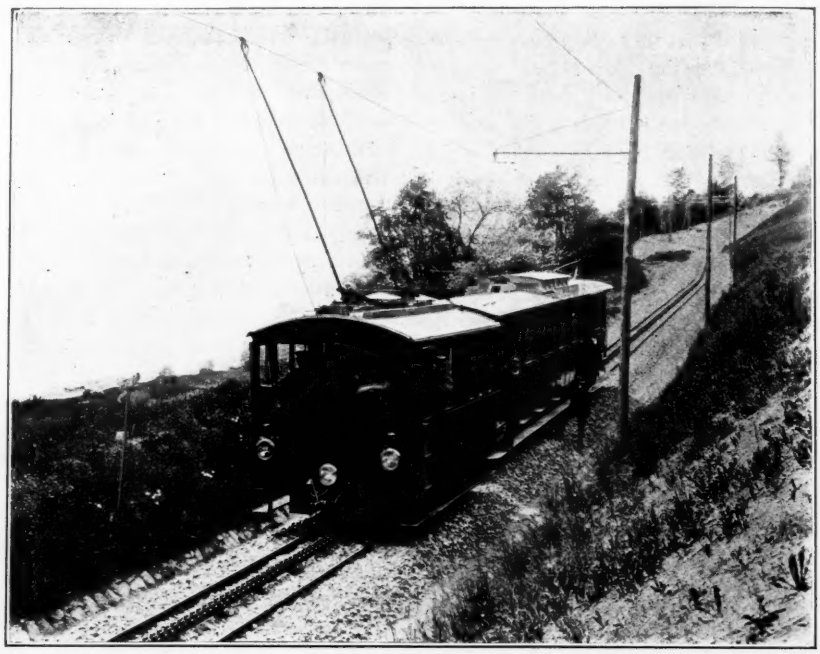


FIG. 1.—VIEW OF ROAD ON BEX-GRYON-VILLARS SYSTEM.

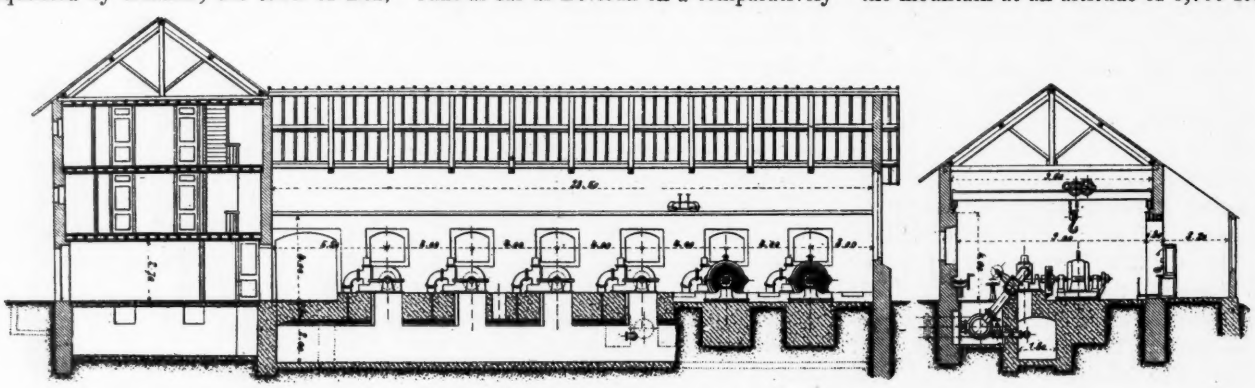


FIG. 2.—HYDRAULIC PLANT AT SUBLIN.

The engraving Fig. 1 shows a view of the road on the heavy grade. The locomotive is placed in the rear and pushes the passenger car up the grade. The electric locomotives have been equipped by

the Compagnie de l'Industrie Electrique, on the Thury system, which is now in successful use on a number of such mountain roads in Switzerland and other countries. The mechanical part has been built by the Fabrique de Locomotives de Winterthur, a well-known Swiss firm. The present road was the first to use this new system of locomotive. It is equipped with two Thury motors of 100 horse-power each. The current for the motors is taken from an overhead line, which gives 650 volts, direct current, by means of a double trolley. The first section of the road, from Bex to Bevieux, is also equipped with a set of ordinary trolley cars of a smaller size in order to supply the local needs.

The hydraulic plant, Figs. 2 and 3, which supplies current for the traction line and the surrounding districts, is situated on the Avançon, a rapid mountain torrent which is already used for supplying power to other plants. The Sublin plant uses a head of water of 520 feet. The mean output of the stream is 800 litres per second, so that the turbines can use about 1,600 horse-power. From the dam starts an underground conduit 4,500 feet long which is constructed in cement beton, with an oval section, and has a maximum height of four feet.

The canal leads down to a small reservoir which serves as the starting point for the penstock and assures a constant water supply under a variable flow of the conduit. The reservoir is twenty-six feet in diameter and has twelve feet depth; it is built of armored cement. To the right will be noticed the penstock, which runs down a steep grade to the station. It has a total length of 1,350 feet with an interior diameter of thirty-six inches. The overflow conduit also starts from the reservoir and has a length of 1,020 feet, running in an armored cement conduit. The penstock leads to the six main turbines of the station, which have been constructed by Escher Wyss & Company. These turbines give 400 horse-power each and work at 600 revolutions per minute. They are provided with automatic speed governors, which are operated by a small hydraulic motor. The engraving, Fig. 4, shows the interior view of the station. The Sublin plant is equipped with six dynamos in all, and is laid out so as to provide for the lighting and motor circuits of the town of Bex and the neighboring region, as well as for the local tramway line of Bex-Bevieux and the

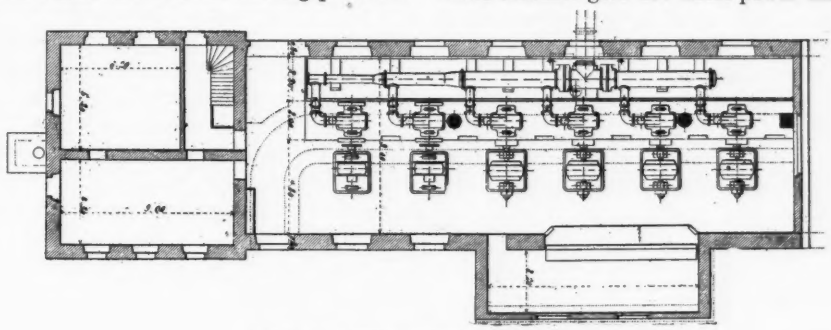


FIG. 3.—SUBLIN HYDRAULIC PLANT.

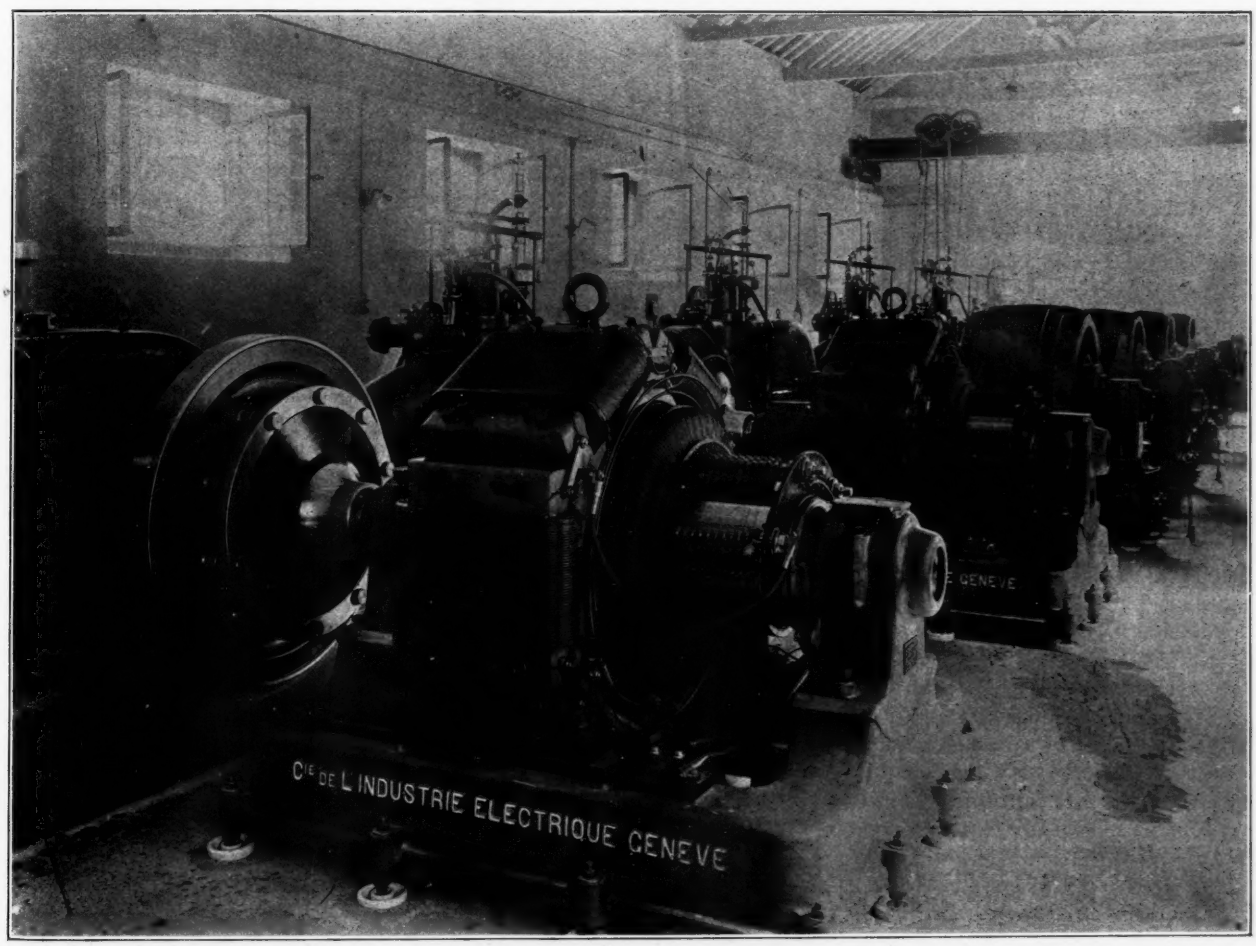


FIG. 4.—INTERIOR OF SUBLIN PLANT.

mountain railway of Bex-Gryon-Villars. For the tramway lines the station has two main generating sets on the Thury direct-current system, one of which is used as a reserve. The remaining four groups are provided with three-phase alternators. The use of the three-phase alternating-current system is now becoming more general in Switzerland and it is replacing the monophase and biphase systems which were formerly used, on account of the advantages it gives both for motor starting and economy in the line. On the other hand, the monophase and biphase current have been preferred for different reasons, especially as they gave a greater facility for regulating the voltage, which is a considerable advantage in stations which combine both lighting and traction systems. But since the rise in the price of copper this latter consideration had to be sacrificed for the sake of economy in the line. Owing to these reasons the triphase current is coming into use in many of the new plants, of which the present station is an example.

The four alternators which are installed at Sublin are designed for 5,200 volts. These machines have been furnished by the Westinghouse company and furnish triphase current at 5,000 volts and fifty cycles, at thirty-three amperes per phase. The exciters are mounted on the end of the shaft. The machine complete weighs 12.2 tons.

The two direct-current generators for the traction lines will be noticed in the foreground. These machines have been built by the Compagnie de l'Industrie Electrique, on the Thury system. They are six-pole machines, which deliver normally 300 amperes at 650 volts. The field windings are over-compounded so as to compensate for the variations of voltage in the traction system. The machines are designed, however, so that the variation in the voltage from no load to full load does not exceed eight per cent at a constant speed and field charge. According to the tests these machines show an efficiency of ninety-three per cent. The total weight of the armature is about three tons, and that of the whole machine in running order nine tons. The commutator is built up of 309 copper strips, and on account of the great number of strips which are used a very uniform voltage line is obtained. The copper of the commutator alone represents a weight of 800 pounds.

The generators are connected to the turbines by an elastic coupling. The flywheel next to the turbine carries a set of pins or projections and a smaller disc lying next the generator has a like set of projections. The two sets of pins are then connected across in pairs by short rubber bands to form the elastic coupling. The floor of the station is covered with a layer of asphalt one and one-half inches thick, which forms a good insulating covering. As will be observed, the machines are bolted down upon a set of porcelain insulators which have been firmly fixed in the flooring. This system of insulation has given good satisfaction. The direct current for the traction lines is taken to the trolley wires by a series of overhead feeders which are connected in parallel. The other pole of the generators is grounded by connecting with the rails of the track at a point near the main station.

The alternators supply the main distribution lines directly without the use of step-up transformers. The system comprises both lighting and motor circuits. All the lighting circuits have been mounted upon one of the phases. The system of distribution will be observed in one of the diagrams. The high-tension lines for the motors use a three-wire line and the lighting circuits a two-wire line. At different points on the main circuit are placed the substations for supplying the low-tension circuits for the lighting or motors. In these stations are placed a set of monophase or three-phase transformers which are connected in parallel in each case. In one instance the high-tension current is used direct at 5,000 volts at the electrolytic plant of Monthey. In this case the alternating current is taken by large synchronous rotary converters of 300 horse-power each, which produce continuous current for the electrochemical work.

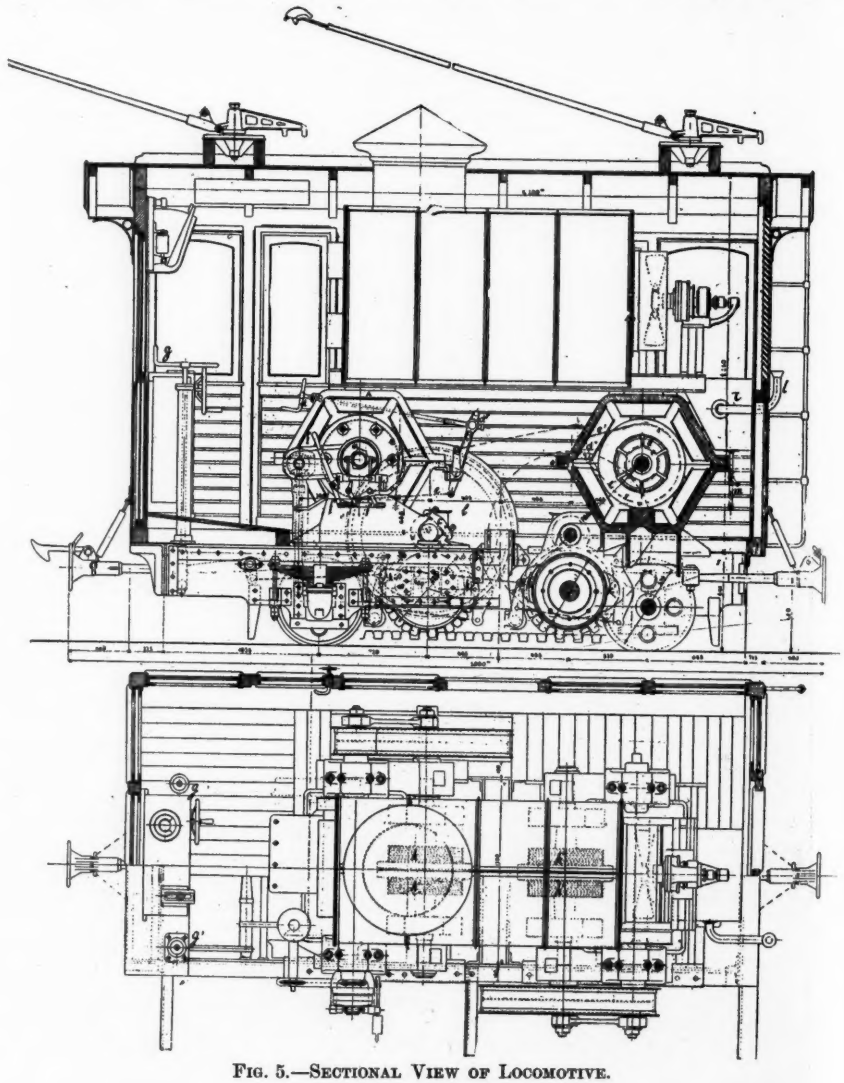


FIG. 5.—SECTIONAL VIEW OF LOCOMOTIVE.

The sectional view, Fig. 5, of the locomotive used on the traction line shows the general arrangement of the system and the method which has been adopted for mounting the two 100-horse-power motors, with the sets of gearing used for operating the rack-and-pinion mechanism.

The total length of the locomotive over the connecting pieces measures sixteen feet. The distance between the main axles is seven feet three inches, and the distance between the shafts of the gear wheels of the rack-and-pinion three feet one inch. The locomotive has a total width of eight feet three inches, and a height of seven feet six inches from the rail level to the roof, exclusive of the trolley fixtures. The truck of the locomotive is composed of two strong side-beams of channel iron braced across by smaller bars. This forms a solid base on which is placed the frame or body of the locomotive, which has been furnished by the Société de Neuhausen. The body of the locomotive, which is thirteen feet long, has three windows and a sliding door on each side, also an iron ladder attached in the rear for mounting on to the roof to make repairs to the trolley.

The motor operates the pinion which engages with the toothed rail between the tracks by means of double-reduction gearing. Each set of motor and gears is exactly alike. The toothed rail is double, forming two racks placed side by side with about one-inch space between them. The teeth of the racks are staggered so as to give a better hold. The disposition of the gearing will be observed in the case of the left-hand motor. The first pinion *a*, mounted on the motor shaft, which has only ten inches in diameter, engages with a large gear wheel *b* of forty-three inches diameter. From the gear *b* a shaft passes across the locomotive carrying on the opposite side a small pinion *c*. The latter pinion engages with a gear of twenty-inches diameter which is placed directly below it and mounted upon the axle of the main pinion which engages with the rack. The latter pinion has a diameter of twenty-five inches. The second motor has a like system of gearing which is disposed symmetrically in the opposite direction. The total ratio of speed reduction given by the gear sets is one to eight, and as the motor makes an average speed of 525 revolutions per minute the locomotive has a speed of five miles an hour, as the diameter of the main rack pinion is twenty-five inches. The maximum speed admitted for the locomotives is 7.5 miles an hour.

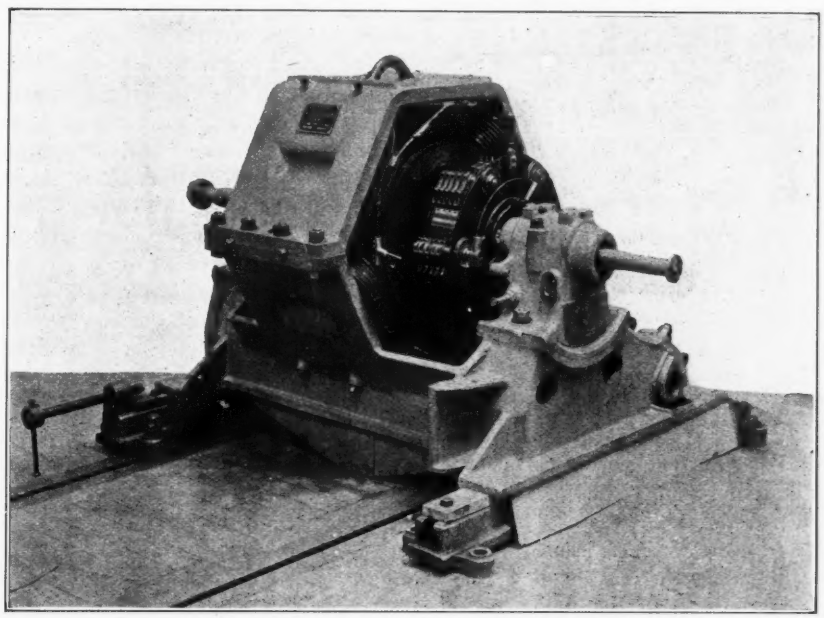


FIG. 6.—MOTOR IN USE ON LOCOMOTIVE.

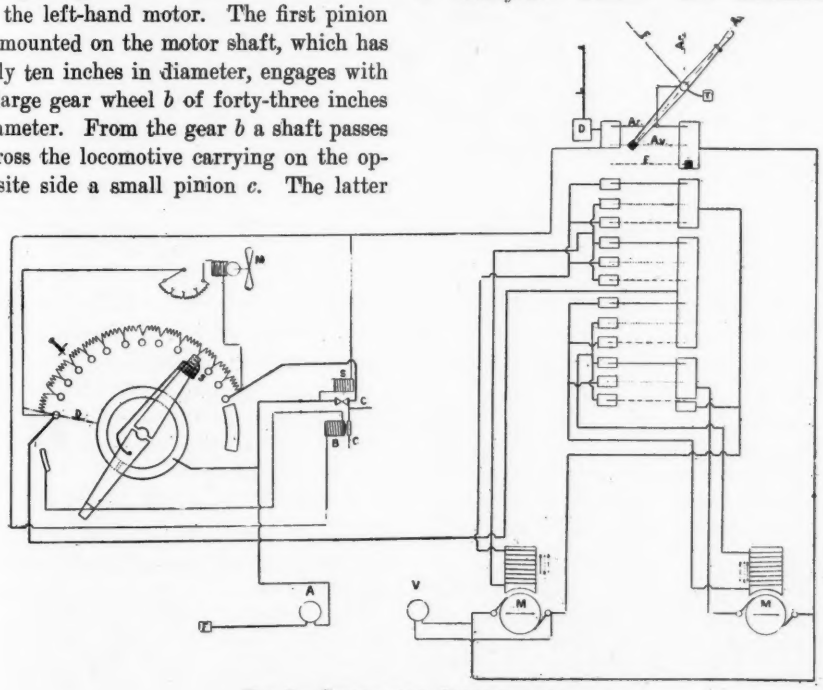


FIG. 7.—CONTROLLER CONNECTIONS.

As the locomotive is designed to mount a steep grade, the system of braking had to be carefully carried out. Three sets of brakes working on different principles have been provided in this case, namely, band brakes working over drums, brake shoes and an automatic brake. The band brakes are placed upon steel pulleys which are mounted directly upon the motor shafts. Above the motor A will be observed the handle *d* which operates a lever *d'*; to the end of this lever is attached one end of a strong steel band *e e e* three inches in diameter which passes around the large pulley on the motor shaft noticed in dotted lines. The band is fixed at the other end and by turning the handle *d* a strong pressure is brought to bear on the drum. The brakes on both motors are operated by the same handle. An automatic device operated by a centrifugal mechanism *ff* acts upon the steel bands when the speed exceeds a certain point and causes a braking action.

A powerful set of hand brakes is also provided. These will be observed in the section view where *h h*, *h' h'* represent two brake cylinders which are mounted on each side of the main pinions. These cylinders are of cast iron and carry a set of annular grooves on the surface in which fit a set of corresponding projections on the brake shoes to provide a strong gripping surface. The brake shoes of bronze, which are noticed at KK' in the sectional view, are thrown on by a series of levers from the crank *g* which is placed next to the controller in the front of the locomotive. In the rear will be observed the water tank *r* which has a set of piping to supply water to the different brakes for keeping them cool. It is filled from the outside of the locomotive at *l*. The disposition of the two trolleys will also be noticed in the sectional view. The total

weight of the locomotives of this pattern is about fourteen tons, and the weight of the passenger car when fully loaded varies from sixteen to eighteen tons.

The motor which has been designed for this type of locomotive will be observed in the engraving, Fig. 6, which shows the disposition of the motor and the foundation casting. These motors have a hexagonal cast-steel body which contains the six field poles cast together with the frame. The armature is of the Thury drum-wound pattern with the winding laid in slots. The field bore is 23.2 inches. The lower bed-plate is cast in one piece and has a flange projection at either end by which the motor can be solidly bolted down to the main side beams of the locomotive. The shaft of the motor, which runs in ball bearings, carries on the outer side the pinion which engages with a set of double-reduction gearing for operating the rack-and-pinion system, as will be further described.

The controller which is used with the present locomotive consists of a rectangular sheet-iron box containing the controller mechanism and has a vertical hand-wheel on the front side and a lever at the top which works over a sector. The controller is composed of two distinct parts, which will be observed in the diagram of connections, Fig. 7. One part consists of a regulating circle for the motor speed composed of twenty-five segments for the resistances, and the second is a series of contacts which is shifted back and forth by the hand lever, as noticed to the right. The regulation of the motor speed by means of the resistance coils is carried out by a central pivoted arm which revolves over the segments. This arm also passes over an inner metal ring which has a ground connection. At the outer end the controller arm is provided with a strong magnetic blowout which suppresses the sparking at the contacts.

As to the arc which is produced when the current is finally cut off, this has been made as small as possible by the following device. The arc formed by the main current is produced in a special apparatus or spark-breaker, which is placed outside the controller case in the roof of the locomotive and is operated by a small electromagnet. This device is shown to the right of the controller circle in the diagram. At the time of breaking the circuit the current is passed into a circuit containing two carbon contacts C, one of which is movable. When the controller arm comes over its last contact plate the current is broken in a small electromagnet B, which holds the carbon contacts together, and the points are separated. The spark which is produced at the contacts is then blown out by the action of the electromagnet S, into which a strong current is passed at this moment. This device is found to work very satisfactorily.

The second part of the controller, which is observed on the right of the diagram, is used for obtaining the direct or reverse running of the motor and for carrying out the electric braking action of the motors by short-circuiting their armatures through a low resistance. This controlling switch is composed of a lever which works over a toothed sector, acting upon a stout rod which shifts the contacts back and forth in a vertical direction. The current which comes from the two trolleys passes

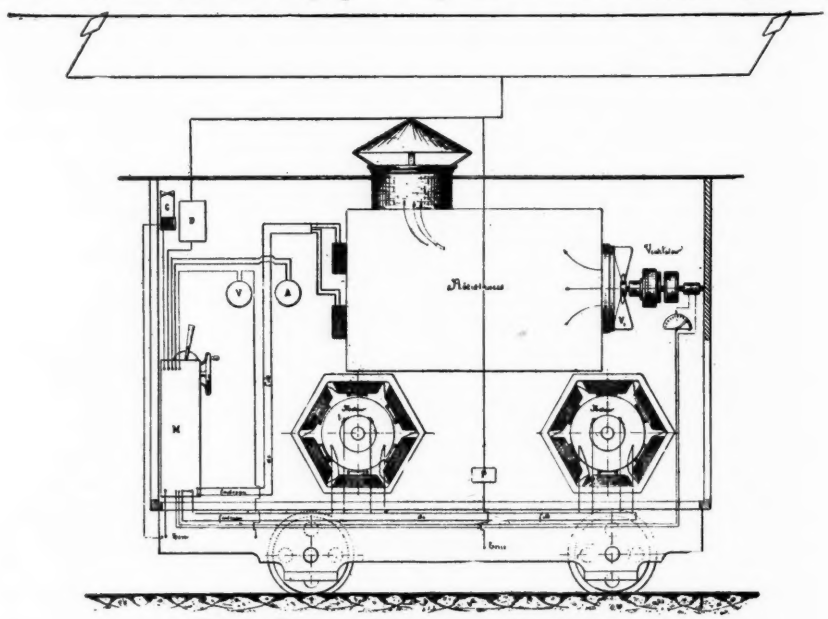


Fig. 8.—Electric Connection of Locomotive.

first through an automatic circuit-breaker D, placed overhead. The circuit-breaker can also be worked by hand in case of need. The current passes through the controller switch and thence to the two motors, which are connected in parallel. From the motors it passes to the resistance coils by means of the circular switch and from thence to the ground circle and to earth.

The diagram, Fig. 8, shows the electrical connections of the locomotive, with the controller M on the left. At D is the automatic circuit-breaker, and at C the magnetic blowout. The resistances are mounted above the motors in a large sheet-iron box. These resistances are formed of strips of corrugated iron whose section is calculated so as to support the total current due to the electric braking action of the motors. On this account they are required to have a much larger size than a set of ordinary starting resistances for the motors. To avoid heating up of the resistances under the heavy currents an effective air-blowing system is provided. In the rear of the resistance case is an electric motor which drives a large air fan. This motor is connected to the circuit of the resistance coils so that it can operate when the locomotive is on the down-grade and the trolleys are taken down, as it is during this time that the resistance heats up the most and the fan is especially needed. In this case the motors of the locomotive run as generators and are connected upon the resistances.

To carry out this manœuvre, as well as to secure the electric braking action, the current from the overhead line is cut off by a switch and a connection is made with the ground by means of the controller lever. The direction of the current in the machines is the same as for the forward running. The motors now act as generators and work directly upon the resistances, and the latter are varied to suit the requirements.

A series of interesting tests was carried out at the time of putting them into practice which showed that they were capable of performing all that the constructors claimed for them. The locomotives were required to push a passenger car of the standard type up a twenty per cent grade. The car was loaded with salt bags up to the maximum weight allowable, or 18.7 tons. Four trips were thus made up the grade at a speed of 4.5 miles an hour. The motors of the locomotive each took a current of 112.5 amperes at 650 volts, thus giving together about 210 horsepower. On the down-grade trips with

the electric brake alone in action the result was all that could be expected, and the speed of the descent could be regulated with ease and also within the widest limits, for the electric braking action comes into full play at a speed as low as a quarter of a mile an hour and works from that point up to the maximum of seven miles an hour, which is not exceeded in practice.

The automatic brake also worked very well on the different trials; it is thrown on automatically when a speed of seven miles an hour is reached and brings the train to a full stop without any shocks and inside of a short distance. In the test of the hand brakes it was found that with a very slight effort the descent of the thirty-ton train on a twenty per cent grade could be stopped within ten or twelve feet. One point to be remarked is the advantage which the electric braking action with direct current has over the polyphase locomotives, as in the former case the locomotive is entirely independent of the line and the machines at the generating station. This gives a great security to the system, especially in the present case where heavy grades are used on the line. Usually the car descends with its trolley poles lowered. Another advantage of the direct current for this application lies in the fact that the speed can be varied within wide limits down to an almost complete stop of the train, while with the polyphase system the electric braking action can only take place when the speed exceeds the normal speed of the ascent corresponding to the synchronism of the polyphase motors with the alternators.

Electric Railway Possibilities in South Africa.

The following interesting discussion of the possibilities of electrical operation of railways in South Africa is taken from the report of Mr. Hoy, the chief traffic manager of the Central South African Railways:

"The success with which heavy locomotive engines are now being employed in these colonies, as well as in England, points to the maximum having been nearly, if not actually, reached. A 120-ton locomotive upon an eighty-pound rail, on a three-foot six-inch gauge, is what would generally be considered a favorable result. If the locomotive limit has been attained, there are evidences of developments in substituting a newer motive power upon lines where the nature of the traffic to be conveyed renders it possible to utilize electrical or other systems of energy. The employment of the heavy locomotive has its unquestioned economic merits, but it is an important consideration whether freight vehicles may not with advantage be equipped with their own motive power, either for individual or collective haulage. The grade will always largely influence the value of the locomotive, but upon sections admirably adapted for the use of electricity, the adhesive power may with advantage be abandoned for the energy attached to the vehicle itself, and thus overcome the resistance common to the present system of haulage. Whether the power to be employed be electricity or a combination of other forces, there can no longer be any doubts, that upon short and busy lines steam can be superseded. If any section of railway in South Africa lends itself for advancement in this direction, the Springs-Randfontein length offers an admirable opportunity for the expansion of such scientific energy. The working of so many mines sidings might assure the success of a change in working. There is a further guarantee of sufficient traffic within the section. I assume that electricity will supersede steam for passenger work along what is known as the Rand tram section within a measurable space of time. There are excellent opportunities for installing electricity, and of taking early steps, not only to cultivate the suburban traffic, but to retain it."

ELECTRICAL NOTES FROM INDIA.

(Special Correspondence.)

During last August all of the motors and compressors operating at the Kolar gold fields, India, were taken over by the operating company from the Mysore Government. This machinery was put in by the Mysore Government under a very liberal guarantee, the agreement being that it should be operated continuously for one year, and if in satisfactory condition it would then be accepted. This machinery is operated by power generated at the power station on the Cauvery river, this being transmitted to the mines at 30,000 volts. There were thirty-one motors in all, including induction and synchronous, and eleven double air compressors. The motors have been running under the care of native attendants who know practically nothing about them and who have a tendency to go to sleep while on watch, allowing oil cups and lubricators to run dry.

Work has been started on the installation of 4,000 horse-power additional to the Cauvery power station, and the building and forebay are being enlarged to provide for this. This will double the output of the station, and to lessen the line loss caused by this increase the voltage of the system will be raised to 35,000.

It is possible that the city of Bangalore will be lighted by power supplied from the Cauvery station, as the transmission line passes within eighteen miles of it, though the town is rather scattered and the lighting load will not be very large. The government pumping station, which is located six miles from the Kolar gold fields, is also to be operated electrically.

It is reported that the city of Madras is considering the installation of an electric railway service in the near future, and that Bombay is contemplating an electric lighting plant. A. C.

Mysore, India, September 19.

ELECTRIC MOTORS FOR CENTRIFUGAL PUMPS AND FANS.[1]

BY AUG. J. BOWIE, JR.

The rapidly increasing use of electric motors for driving centrifugal pumps and fans renders important the study of these loads under the varying conditions encountered in practice. The possible loads which may thus be thrown on a motor, due to variations in speed, or in the head against which it must operate, are serious enough to warrant careful consideration.

The problem of determining the proper capacity of a motor is not always easy to solve. The solution is too often the result of guesswork, and is liable to be seriously in error. In the case of direct-acting pumps working against a known head, the proper motor capacity can be easily calculated. The most economical size of motor for the purchaser, however, may not be solely determined by the possible loads, and their duration, which the motor may be called upon to carry. Particularly is this true where a flat-rate system is in vogue and where power is purchased at a price depending upon the rating of the motor and not upon the power actually used. This system of charging for power leads to great abuse in the underrating of motors; on the other hand, it may work a great hardship on a purchaser of power who innocently uses a motor far larger than is necessary and pays for power that is not consumed. Several instances of the latter have come under the writer's observation, and the system in his opinion should be condemned. Where measurements of power are taken as a basis for determining the flat rate, such measurements should be taken under the average running conditions. A variation in these conditions may lead to a very erroneous system of charges in the case of centrifugal pumps and fans, as will be seen later.

For centrifugal pumps and fans the power required for operation at a rated speed and head is by no means all that need be known. One should also know the maximum load which can ever come on a motor when driving the pump or fan at the rated speed and under any possible head. This maximum may be far in excess of the rating.

The problem in case of centrifugal pumps and fans will be treated under the following three heads: (1) Constant speed and varying heads; (2)

[1] A paper read at the 179th meeting of the American Institute of Electrical Engineers, New York, September 25, 1903.

changing speed with head varying directly as the square of the speed; and (3) constant head and varying speed.

I—CONSTANT SPEED.

The following treatment applies equally well to centrifugal pumps and to centrifugal fans, as the same laws govern the flow of either fluid, but pumps alone will be considered. Represent by H the head generated by the pump. This is equal to the difference between the discharge and suction pressures, plus the difference between the discharge and suction velocity heads. Represent by Q the cubic feet of water discharged per minute. The general equation expressing the relation between Q and H is $H = A - B Q^2 + C Q$, where A, B, and C are constants.

This is the equation of a parabola, and it will approximately represent the actual curves obtained in practice. Back-slippage through the running wings of the pump has not been taken into account in the above equation, and will account in part for discrepancies between theoretical and actual results.

The pressure exerted by the pump is a maximum when $D\ q\ H = 0$. Hence, when $2\ BQ = C$, $Q = \frac{C}{2B}$, and $H = A \div \frac{C^2}{4B}$, is the maximum value.

Let W_0 = output of pumps in watts. $W_0 = KHQ$, K being a constant. $W_0 = KQ\ (A - BQ^2 + CQ)$. This is a maximum when $D\ q\ W = 0$, or

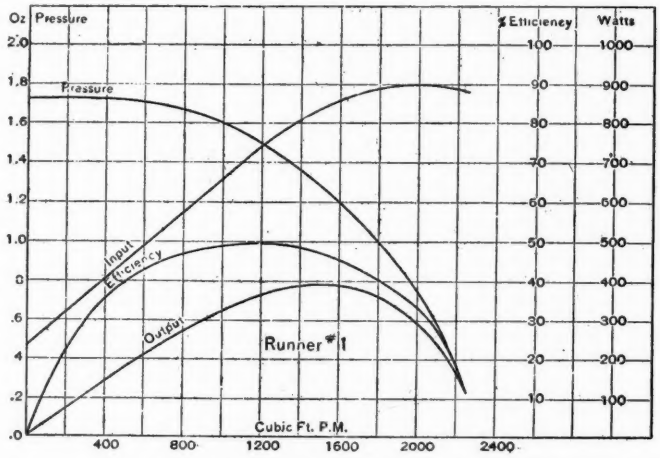
$A - 3\ BQ^2 + 2\ CQ = 0$. $Q = \frac{C}{3B} \pm \sqrt{\frac{A}{3B} + \frac{C^2}{9B^2}}$, corresponding to $H = \frac{2}{3} A + \frac{1}{3} CQ$.

In some pumps the constant C is so small that it may be disregarded. In this event the maximum head is obtained at zero discharge and is equal to A. The maximum output of the pump is obtained at a head of $\frac{2}{3}$ A. The relative values of C and B determine the nature of the output curve of the pump and the maximum obtainable pressure. If B be fixed, the greater the value of C the greater will be the capacity of the pump. If C be fixed, the less the value of B the greater will be the pump capacity. However, the relative values of C and B will have a very important bearing on the ratio between the maximum power required to run the pump, and the power required to run it at the point of highest efficiency, or at the point of maximum output.

The quantity $\frac{C}{B}$ is influenced largely by the angle which the vanes of the pump make with the radial at the external periphery, as well as by the width of the face of the runner. However, it is beyond the scope of this paper to enter into a discussion of the design of pumps, other than in a general way, so as to show the effect of the design upon the maximum power required to drive the pump. Usually this power will increase as the effective head of the pump decreases. This would naturally be expected as long as the energy output of the pump is on the increase, but after the latter starts to decrease it might be considered natural to look for a decrease of the driving power. However, when B is fixed, the smaller the value of C the less will be the tendency of the pump to require additional power to drive it at heads lower than its rated capacity, and the higher the value of C the greater will this additional power become. When C is fixed, the reverse holds true for B.

A centrifugal pump, when operated at too low a head, shows a very low efficiency. In general, however, with a well-designed pump, the range of efficient operation for a constant speed is fairly broad. The principal point which the writer wishes to bring out in this connection is the danger of overloading a motor through too low a head. A manufacturer will usually guarantee a certain efficiency and input for a pump at its rated load, but will say nothing concerning the power required to drive it at heads lower than that called for. The question may arise, why not give a pump the proper speed for a given head? This is frequently impracticable, since pumps must often be installed to work under widely varying heads, where it is not an easy matter to change the speeds. Oftentimes the heads at which the water must be elevated may vary practically from zero to the maximum head against which the pump will deliver. In some cases these overloads may be of long duration, and a sufficiently large motor should be installed. On the other hand, the maximum load will often be only of short duration, as for example in the case of pumping from a well, particularly where there is a pit in connection with it, which is partially filled up with water. Generally it will not take the pump long to very decidedly lower the water, and the duration of overload will be brief.

The behavior of centrifugal pumps may be represented very completely by four curves. These curves are based upon an absolutely fixed speed. Corrections for variations from this speed may be made without difficulty. These curves have,



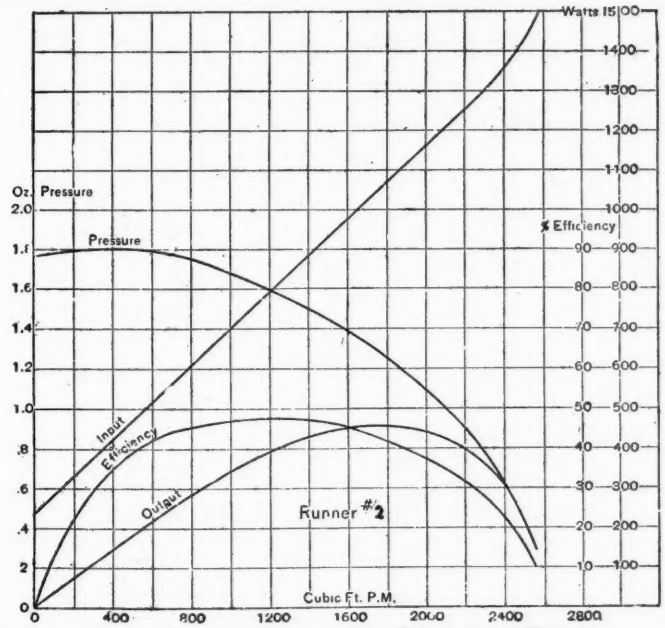
CURVES SHOWING OPERATION OF CENTRIFUGAL PUMP.

in each case, for abscissæ, the volumes of the fluids delivered in a fixed time interval, while for ordinates they have respectively, head, watts input to pump, watts output from pump, and pump efficiency.

The last two curves determine the proper rating of the pump. In general, the maximum efficiency occurs before arriving at the point of maximum output. The proper rating is somewhat indefinite, as will appear from the appended curves obtained in practice. The natural tendency of a manufacturer is to rate his pumps as high as possible. Still, he does not care to go far beyond the point of maximum efficiency at the full load rating.

The accompanying curves show the results of tests on two fans with the same casing, but with different runners. In the first set $\frac{C}{B}$ is smaller than in the second set. According to the curves,

the first fan is of smaller capacity, but of higher efficiency than the second. Particularly noticeable is the curve of watts input, which in the first case shows a decided concavity towards the X axis, shortly after passing the maximum output of the pump. While in the second case the corresponding curve, on the contrary, becomes slightly convexed toward the X axis, and requires far more power under low heads. Thus the ratio of maximum outputs is 1.15, and the ratio of maximum inputs, within the range of the tests, is 1.68. These fans represent by no means extreme conditions. In the case of the second fan, if it should be called upon to operate under the lowest head tested, and if it were rated at the point of maximum efficiency and a corresponding motor were installed, then this motor would be liable to an overload of eighty-nine per cent.



CURVES SHOWING OPERATION OF CENTRIFUGAL PUMP.

II—CHANGING SPEED WITH HEAD VARYING AS THE SQUARE OF THE SPEED.

If a centrifugal pump delivers Q cubic feet of water per minute, against a pressure of H feet while running at R revolutions per minute, and then if the speed be altered to $R_1 = KR$, it will deliver $Q_1 = KQ$ cubic feet per minute against a pressure $H_1 = K^2H$ feet. If W = watts output of pump in the first case, and I = watts to pump, then $W_1 = K^3W$, and $I_1 = K^3I$. These equations follow from the proportionality between the head generated and the square of the speed, and because, when the volumetric output varies directly as the speed, the relative angles of motion of the water are not altered. Furthermore, all frictional losses vary as the cube of the speed, and all volumetric leakage losses vary as the speed. Hence it follows that increasing the speed of the runner, where the effective head varies as the square of the speed will result in increasing the capacity of the pump directly as the speed, and increasing the power input and output directly as the cube of the speed. The conditions presupposed in this case, namely, that the head varies as the square of the speed, is the condition which exists in the case of ventilating fans, where the head is used up in friction in the pipe, and in the velocity head of discharge from the pipe. This velocity head, and also the friction head vary as the square of the discharge from the pipe.

What concerns the motor capacity particularly is the fact that the power varies directly as the cube of the speed. Hence the I^2R loss in the armature varies as the sixth power of the speed.

III—CONSTANT SPEED.

This is the condition which exists when pumping against a fixed lift, when the velocity heads lost at entrance and discharge, and when the fractional losses in the pipe may be disregarded in comparison with the lift.

In this case, and likewise in case 2, the characteristic curves of a pump under variation of speed can be obtained from those at another speed by multiplying the quantities discharged by the ratio K of the speeds, the pressures by K^2, and the watts input and output by K^3. The efficiencies remain the same.

It is evident that the apparatus of case 3 will operate at a point situated further along on the curves than that of case 2; the result being a greater delivery of water, and, usually, a greater input to the pump. In general this input will vary faster than the cube, and not as fast as the fourth power of the speed. As an approximation say as the three and one-half power of the speed. This makes the I^2R loss in the armature vary as the seventh power of the speed. Thus ten per cent increase in speed represents forty per cent increase in power and ninety-six per cent increase in the I^2R loss in the armature. From this it may be seen what an extremely large effect speed variation has on motors driving centrifugal apparatus. There is perhaps no other form of apparatus so sensitive to change of speed in its power consumption. The effect which a steady pump load has in holding the voltage constant by preventing the racing of generators is thus explained.

If centrifugal apparatus be provided with induction or synchronous motors then the speed is practically fixed by that of the prime mover, so that the maximum load for the motor with a given pump or fan is determined.

Speed control of direct-current motors by variation of field resistance has a limited range in practice and has many points which tend to make it objectionable for the best conditions of commutation. Even at best there will be considerable field distortion at the high speeds. The effect of a load which would increase as the cube of the speed, and even faster, would seem to limit still further the allowable speed variation to be obtained in this manner. In view of these facts it is well to provide a motor of ample size for such work and at the same time to see that the field rheostat can not cut in so much resistance as to overload the motor. As has been shown, the volumetric output of a centrifugal pump varies directly as the speed of revolution. In spite of this fact, many manufacturers rate their pumps at a fixed volumetric output, and publish a list of suitable speeds for different heads under which it may be desired to operate the pump. In some cases the highest speed given in these lists is three, or more times as great as the lowest speed. Such misinformation leads to a great deal of trouble and can not be too strongly condemned.

In regard to the statement previously made, that the efficiencies of pumps and fans were independent of the speed, proper changes being made for head and discharge, no consideration was taken to the effect of unbalance of the runner or of bearing or stuffing-box friction. These, of course, would modify the results obtained. Lack of proper running balance is very apt to cause serious loss of power.

The British Association for the Advancement of Science.

Meeting at Southport, England, September 9, 1903.

From Our Special Correspondent.

THE 1903 meeting of the British Association was held at Southport and commenced on Wednesday, September 9, concluding on Wednesday, September 16. This was the second visit paid by the association to this seaside health resort, the first occasion being some twenty years ago. The present meeting was the seventy-third annual session, and the president this year was Sir Norman Lockyer, K. C. B., LL. D., F. R. S.

As a first duty, Sir Norman referred to the great loss which the nation has sustained in the death of Lord Salisbury, and, in dilating upon the fact that this politician had also occupied the proud position of president of the association (and the present Premier, Mr. A. J. Balfour, having accepted the same position for next year), he came at once to the theme of his lecture; *viz.*, the influence of brain power on history. The nineteenth century would ever be known as the one in which the influences of science were first fully realized in civilized communities, scientific progress being so gigantic that it seemed rash to predict that any of its successors could be more important in the life of any nation. At the same time, however, there was a great necessity in Great Britain for a body dealing with the organization of science. The present awakening in relation to the nation's real needs was largely due to the warnings of men of science. During many years it had been a part of his duty to consider such matters, and he had been driven to the conclusion that our great crying need was to bring about an organization of men of science and all interested in science similar to those which proved so effective in other branches of human activity. For the last few years he had dreamed of a chamber, guild or league with a wide and large membership which could give us what, in his opinion, was so urgently needed. The foundation of such a body was the British Association itself, and they could rest assured that sooner or later such a guild would be formed. He believed the association would be a vast gainer by such an expansion, *viz.*, a British science league, on the lines, for instance, of the German navy league. Our position as a nation, our success as merchants, was in peril chiefly because of our lack of completely efficient universities and our neglect of research. From neglect of research came imperfect education, and a small output of new application and new knowledge to reinvigorate our industries.

Chief among the causes which had brought us to the terrible condition of inferiority, as compared with other nations, in which we at present found ourselves was our carelessness in the matter of education and our false notions of the limitations of state functions in relation to the condition of modern civilization. As an analogy he compared the navy with education. In the early days the navy was largely a matter of private and local concern, but all this had passed away. Again, time was when not a penny was spent by the state on elementary education. But when we passed from primary to university education, instead of state endowment we found state neglect. We appeared to be in a region where it was nobody's business to see that anything was done. What were the facts relating to private endowment in this country? In spite of the munificence displayed by a small number of individuals in some localities, the truth must be spoken. In depending in Great Britain upon this form of endowment we were trusting to a broken reed. Taking the twelve English university colleges private effort, during sixty years, had found less than $20,000,000. Against this, in the United States, during the last few years, the universities and colleges had received more than $200,000,000 from this source alone, and private effort had supplied nearly $35,000,000 in the years 1898 to 1900. Likewise in Germany, state aid was considerable. The buildings of the new University of Strassburg had already cost nearly $5,000,000, which was about as much as had yet been found for buildings in Manchester, Liverpool, Birmingham, Bristol, Newcastle and Sheffield. But in Great Britain, the state really conceded the principle, for its present contribution to our universities and colleges amounted to $830,000 a year.

After dealing with the importance of research work, as the most powerful engine of education we possessed, the address concluded with a reference to the need of a British scientific national council.

The sectional meetings commenced on the following day, Thursday, September 10. The following are the presidents of the sections devoted to engineering and allied subjects: Section A, mathematical and physical science, Professor C. Vernon Boys, F. R. S. Section B, chemistry, Professor W. N. Hartley. Section G, engineering, Charles Hawkesley. Section L, educational science, Sir W. de W. Abney, F. R. S.

Section A—The president's address paid an eloquent tribute to the memories of the many men of science who have passed away during the past twelve months in Great Britain, Germany and the United States. The subject matter of his discourse had reference to the much discussed question of the discovery of radium, in which he briefly reviewed the work accomplished by the various physicists who have taken this matter up.

The papers read in this section on the first day were of a peculiarly similar character as the following list will show: "On Electro-Etheral Theory of the Velocity of Light in Gases, Liquids and Solids," by Lord Kelvin; "On the Nature of the Emanations from Radioactive Substances," by Professor E. Rutherford (this was followed by a discussion in which many important persons took part); "On the Radioactive Emanations Present in the Earth's Crust and Atmosphere," by Messrs. Elster and Geitel; "Cosmical Radioactivity," by Professor A. Schuster; "The Production of Helium by Radium," by Sir W. Ramsay, F. R. S., and W. F. Soddy, and "Intersification of Chemical Action by the Emanations from Gold and Platinum," by G. T. Beilby. Obviously, it is impossible in this brief summary to give in detail all these important contributions, more than one of which, however, recounted the existing knowledge on the subject. It was noticeable, however, that the biggest discussions took place upon papers of this character rather than upon those on purely engineering subjects. The paper by Mr. James Swinburne upon "The Treatment of the Thermodynamics of Irreversible Processes" was discussed briefly.

Section G. Engineering—Mr. Charles Hawkesley's presidential address to this section dealt with many practical matters. First of all intercommunication. At the commencement of the nineteenth century we were told there was not a mile of tramway in the United Kingdom. Now there

are about 22,000 miles. From that commencement the improvement of the condition of the public roads followed as a natural necessity for speed in locomotion. A burning question at the present time was the speed of motor cars along public thoroughfares. However, electric cars were a luxury, like the petrol motor, which, nevertheless, had a wider field of application and a greater degree of prosperity than electrically propelled vehicles. The use of "standardized accumulators" to be supplied to the owners of electrical vehicles at depots on production of a subscription ticket had been suggested, and the engineering standards committee had appointed a subcommittee to consider the question. Turning to electric tramways and light railways, the president did not think it could be regarded as fair to the railway companies—which had to pay large sums of money for the land upon which their lines had been constructed—to have to compete with tramways which were laid along public roads without payment being made for their use. The roads were disfigured by aerial conductors and the supporting posts by which the electric current was conveyed to the cars, except on those comparatively rare instances in which the conduit system was employed; neither could it be denied that tramways greatly interfered with the use of the roads for ordinary traffic. Further, the effect of electrolytic action on iron pipes laid beneath the roads was still undergoing investigation. In saying a few words upon wireless telegraphy, the opinion was expressed that there appeared to be a practical field for the development of wireless telegraphy more especially where ordinary telegraphy could not be applied, as, for instance, between shore and ships and ships at sea, or between one ship and another.

"Improvement in Locomotive Design" was the title of a paper read by Mr. T. Clarkson, dealing with some improvements he himself had effected in steam-driven cars. He attributed the fact that so many flimsy cars of the internal combustion type had been put upon the market to the great popularity of these cars, and it was very satisfactory that so few accidents had occurred. In the discussion great praise was bestowed upon the author for his improvements in steam cars.

Lieutenant-Colonel Crompton next read a paper entitled "The Problem of Modern Street Traffic." Very early in the paper attention was drawn to the somewhat startling fact that in most great cities to-day progress could never be made at a higher average speed than five miles an hour. In fact, slower than forty years ago. This state of affairs having been brought about by the heterogeneous description of vehicles which at present crowded our streets all going at varying speeds; the establishment of a special department of police to supervise street traffic was suggested. Among the functions of the proposed body were the advising of local authorities in drawing up by-laws and also with regard to new crossings, subways, tramways, etc. A great consideration was the regulation of vehicles overtaking others. It was also advocated that no speed limit should be enforced in towns, and this was especially desirable with motor cars which were under far greater control than horse-driven vehicles. Electric automobiles he considered the vehicle of the future.

Mr. W. B. Woodhouse read a paper on "Protective Devices for High-Tension Electrical Devices." This paper advocated, among other things, the use of needle points in air as most reliable for relieving excessive pressure rise, which was questioned, however, in the discussion. The old switch was also eulogized as a useful device, mention was also made of an Italian interrupter consisting of three water jets.

A paper by Mr. J. B. C. Kershaw on the use of aluminum as an electrical conductor referred to some further work by the author, in which he found bare aluminum wires, when exposed under conditions similar to those which might be anticipated if overhead wires for electrical transmission purposes were used, actually gained in weight. Wires suffered more from pitting and corrosion than thick rods. A comparison of galvanized iron wires, exposed under precisely similar conditions, lost in weight. His conclusion was that commercial aluminum lost from 0.9 per cent to three per cent in strength, and gained largely in resistance. Mr. B. Hopkinson remarked that an attempt to use aluminum wire at Leeds as a trolley wire on the tramways there had not been altogether successful.

Professor E. Wilson had two papers, one "The Electrical Conductivity of Certain Aluminum Alloys as Effected in Exposure to London Atmosphere," and "A Method for Finding the Efficiency of Series Motors." The former referred to some aluminum wires, or rather some wires of aluminum alloy, which were placed upon the roof of Kings College, London, in order to investigate the effect of exposure to London atmosphere. The specimens were in the form of wire 0.126 inch (3.2 millimetres) diameter and were placed on the roof on June 11, 1901, and were the subject of communications to the British Association and the Institution of Electrical Engineers in 1902. Since then they have been exposed for another year. The results are given in the accompanying table:

No. of Specimen.	Analysis.						Specific Resistance in 10^{-6} Ohm at 15 Degrees Centigrade before Exposure in 1901.	Percentage Variation of Electrical Resistance at 15 Degrees Centigrade.			Breaking Load in Pounds per Square Inch of Cross Section.
	Si.	Fe.	Cu.	Ni.	Mu.	Zn.		During 1901–2, Taken on Value in 1901.	During 1902–3, Taken on Value in 1902.	During 1901–3, Taken on Value in 1901.	
16	0.31	0.37	0.11	..	..	..	2.92	1.04	0.65	1.69	26,600
4	0.38	0.25	0.16	..	..	..	2.88	1.86	1.10	2.98	25,700
13	0.38	0.25	1.58	..	..	..	3.34	3.49	1.79	5.33	39,000
14	0.40	0.31	1.86	..	..	..	3.25	5.24	1.52	6.84	40,600
15	0.40	0.40	2.61	..	..	..	3.34	6.69	2.77	10.15	43,500
1	0.38	0.22	0.17	..	..	0.62	2.86	3.54	1.05	4.62	28,100
2	0.43	0.28	0.30	..	..	1.20	2.94	2.67	3.09	5.84	30,500
5	0.43	0.39	0.09	..	..	2.04	3.07	2.33	1.14	3.50	26,000
7	0.37	0.25	0.05	0.75	..	..	3.05	1.22	0.73	1.96	29,700
8	0.35	0.29	0.09	1.19	..	..	3.24	2.10	0.11	2.22	33,700
20	0.37	1.10	0.06	2.25	..	..	3.18	1.55	0.23	1.78	38,600
24	0.35	1.16	0.09	..	..	..	2.97	0.765	0.76	1.53	31,300
3	0.37	0.28	0.59	..	..	0.59	3.06	2.52	0.82	3.36	30,500
6	0.39	0.31	0.63	..	..	1.20	3.12	2.02	0.12	2.14	30,900
17	0.35	0.53	0.10	0.83	..	0.90	3.03	0.63	0.50	1.13	31,700
12	0.31	0.59	0.19	1.09	..	0.73	3.33	1.26	1.02	2.24	31,700
18	0.43	0.40	0.21	1.13	..	1.94	3.24	2.29	1.07	3.38	34,500
19	0.35	0.29	0.11	2.01	..	1.77	3.26	2.60	0.81	3.43	36,200
11	0.39	0.56	0.24	2.31	..	0.38	3.48	1.95	0.425	2.38	34,500
22	0.37	0.43	1.08	1.29	..	..	3.41	—1.42	3.96	2.48	45,900
21	0.39	2.57	0.10	1.39	..	..	3.24	—0.97	3.28	2.27	42,200
10	0.32	0.54	0.02	..	0.05	..	3.09	0.783	0.31	1.09	29,200
9	0.31	0.35	0.03	..	0.35	..	3.30	1.94	—0.55	1.39	30,500
23	0.44	0.56	0.09	..	1.78	..	3.49	2.34	..	2.34	35,300
Al.[1]	0.14	0.31	..	..	..	..	2.76	not exposed	2.70	..	28,200

[1] Commercial aluminum.

Mr. B. Hopkinson's paper on "The Parallel Working of Alternators" considered a dynamo. He considered a dynamo connected to a source of supply of constant amplitude and periodicity, and driven by a constant power or working against a constant resistance. He supposed the dynamo and the generators had the same number of poles; then the dynamo would run with the same angular velocity as the supply generators, but with a certain difference of phase dependent on its excitation and on its load or driving power. If that state of steady motion were disturbed the dynamo would make oscillations, sometimes running ahead and sometimes lagging behind the position of steady motion. When ahead of the position it would take less, and when behind it would take more, than its proper supply of energy from the mains. The practical problem was to keep these oscillations, with their accompanying fluctuations in the flow of energy to or from the main, or bus-bars, within moderate limits. The author's mathematical explanations would take up too much space here.

A paper by Mr. J. W. Thomas on the "Ventilation of Tube Railways" described the scheme of ventilation for the Central London Railway, which utilizes both the natural heat in the tunnel as well as the motion of the train.

"Single-Phase Repulsion Motors," by Mr. W. Cramp, considered at great length the winding of commutators of these motors and described some experiments made with a view to improving the utility of these motors.

The presidential address to Section L, educational science section, was by Sir William de W. Abney, F. R. S. It dealt with education in science, and gave the history of state-aided scientific training to the artisan population. His main object in doing this, he said, was because he was confident that ninety-nine educationists out of one hundred had but little idea what the state had been doing for the past fifty years. He knew of some people connected with secondary schools who were, until recently, actually ignorant that financial assistance was offered them by the state.

Captain E. W. Creak, F. R. S., in his address to the geographical section, taking a somewhat different course to that usually followed by earlier presidents of that section, brought to the notice of his audience the subject of terrestrial magnetism in its relation to geography, in order to show that much could be done by the traveler on land and the seaman at sea in helping to fathom the mysteries connected with the behavior of the freely suspended magnetic needle, as it was carried about over the great needle, the earth, by observations in different regions. It was known, he said, that the normal distribution of the earth's magnetism for any epoch was in many localities seriously affected accordingly as the nature of the country surveyed be mountainous, or generally a plain, in the form of islands (or mountains standing out of the sea), and from land under the sea. There was also reason to suspect that the magnetism of that portion of the earth covered by the ocean differed in intensity from that portion of the dry land. A connection between the disturbances of the earth's crust in earthquakes and disturbances of the magnetic needle also seemed to exist, although the evidence on this point was not conclusive. The discourse then went on to treat of magnetic surveys, the magnetic poles of the earth, local magnetic disturbances and terrestrial magnetism and geology. The hope was entertained that geographers would become more interested in a subject so important to pure science, and in its practical applications, and that it would become an additional subject to the instruction which travelers could now obtain under the auspices of the Royal Geographical Society in geology, botany, zoology, meteorology and surveying. There was a wide field open to magnetic observers, and where results often depended so much upon locality, it was necessary that more and more exploration should be made with the magnetic needle. To look over the great oceans and think how little was being done for terrestrial magnetism was a matter for great regret. Yet even here we could be hopeful, for the United States Coast and Geodetic Survey authorities were making arrangements to fit out its vessels with the necessary instruments for determining the magnetic elements at sea.

Another paper read before the engineering section G was one by Mr. F. B. Behr, the expert in high-speed mono-rail railways. He said he had not been able to effect an alteration in his plans which would be a distinct improvement and add a great deal to the comfort and safety of passengers. The great opposition to his invention up to the present had been that the guide wheels which went in the curve had necessarily to go with the bogey and therefore could not get a fair contact with the rails on that side. Needless to say, he did not agree with this any more than he did with the argument that the centrifugal force developed when traveling at 110 miles an hour was too enormous for comfortable traveling. But seeing danger in all this opposition he had set to work to dispose of it. The result was that the pressure produced on the inside of the curve, which required a certain amount of electrical force to overcome it, had been very largely diminished and the carriage could be inclined to any angle with absolute safety.

The report of the committee on electrical standards concluded as follows:

(1) The original British Association unit and the standard ohm based on it could be recovered from the wire coils of the association; (2) the Board of Trade unit was now less than the laboratory unit by 0.006 per cent; (3) the laboratory unit was less than the international ohm by 0.009 per cent; (4) the Board of Trade unit was less than the international ohm by 0.015 per cent; (5) the mercury tubes made at the National Physical Laboratory to represent the international ohm were less than those made at Reichsanstadt by 0.0015 per cent.

Before the engineering section on Tuesday, September 15, a paper by Mr. W. F. Goodrich dealt with the question of refuse disposal which is being largely entertained in connection with electric lighting in the country. He did not commend the American system of "cooking" and chemically treating the garbage, as this still left the bulk of the waste to be disposed of. The real improvement during the past twenty-five years had been the introduction of consumption by fire at high temperature, a system which rendered nuisance impossible besides showing the value of the destructor as a power producer in combination with electricity works. Twenty-five years ago only twelve destructor cells were in use, to-day there were 1,650 in 180 towns. On the continent and the colonies large British destructors were being constructed, and he thought that Great Britain would be pre-eminent in this branch of engineering for many years to come.

A large number of papers were of such a character that no useful abstract could be prepared for such a report as this, and could only be valuable when printed in full. As usual the full importance and benefit of papers read will take time to manifest themselves, as in many instances copies of the full papers were not available, and I believe, no official verbatim report is published by the association. At present, however, the two great outstanding subjects are technical education and radium, the amount of time devoted to these two matters being far greater than any of the others. A. W.

London, September 26.

THE PARALLEL WORKING OF ALTERNATORS.[1]

BY B. HOPKINSON.

The question of the parallel working of alternating-current dynamos, under which term may be included the working of synchronous motors and of rotary converters, has been much discussed during the twenty years which have elapsed since it was first shown that it could be done. No very definite result, however, has been arrived at from the theoretical point of view, though engineers have evolved various empirical rules of design, and have produced the well-known "amortisseurs," in consequence of which the difficulties of parallel running have ceased to be serious, and the theoretical problem has lost much of its importance. Of late, however, a new interest has been given to the discussion of this question by the introduction of large gas engines, with which it is more difficult than with steam to satisfy the requirements of the dynamo designers as to the uniformity of angular velocity necessary for satisfactory running. In this paper I do not propose to add much new matter to the discussion, but rather to attempt to coordinate the mathematical treatment of the subject with the practical rules which have been framed, and which are now regarded as good standard practice, and to point out the reason for certain phenomena which have been observed. It would appear that hitherto the mathematical treatment of the subject has been carried out without sufficient reference to practical conditions, and on the other hand it is possible that the empirical rules of practical engineers, though their success is a sufficient guarantee of their correctness under the conditions to which they have been applied, may not be fully applicable without modification to the new conditions which have followed the introduction of the new types of prime mover.

Dynamically, the question of the parallel working of alternators, or the running of a synchronous motor or converter, is a problem of oscillation about a state of steady motion. Consider an alternating dynamo connected to a source of supply of constant amplitude and periodicity, and driven by a constant power or working against a constant resistance. For simplicity of expression we may suppose that the dynamo, and the generators giving the supply, have all the same number of poles. Then the dynamo will run with the same angular velocity as the supply generators, but with a certain difference of phase which we may call a ϵ dependent on its excitation and on its load or driving power. This is the state of steady motion. If that state be disturbed —say by temporarily varying the load on the dynamo if working as a motor—the dynamo will make oscillations about it, sometimes running ahead of and sometimes lagging behind the position of steady motion. When ahead of that position it will take less, and when behind it will take more, than its proper supply of energy from the mains.

The practical problem is to keep these oscillations, with their accompanying fluctuations in the flow of energy to or from the mains or bus-bars, within moderate limits.

The oscillation may be either free or forced. To clear the ideas we may consider the case of a dynamo working as a synchronous motor, but the results are immediately applicable to the case of a generator. Suppose that the load on the motor is slightly increased. The motor will take up a position in which the phase difference between it and the generators is rather greater than before, becoming, say, $\epsilon - \xi$ where ξ is reckoned positive in the direction of motion of the motor. The torque developed by the motor which was T, is now $T - \xi \frac{dT}{d\epsilon}$ or, say, $T - c\,\xi$. The constant c is readily calculable from the electrical constants of the machine. If now the additional bit of load $-c\,\xi$ be removed there will be a balance of torque of that amount available for accelerating the motor, which, accordingly, will proceed to catch up, so to speak, the state of steady motion. After a time it will arrive at the position of steady motion corresponding to torque T (for which, of course, $\xi = 0$), but will then be moving with more than the steady motion velocity. In consequence of the difference of velocity, the motor will not exert quite the steady motion torque T, but there will be a balance of torque tending to accelerate it or retard it. This, if the difference in velocity is small, will be proportional to that difference and equal, say, to $b \frac{d\xi}{dt}$. Adding the effect of this and of the term $c\,\xi$, we find the equation of motion of the motor

$$M \frac{d^2\xi}{dt^2} + b \frac{d\xi}{dt} + c\,\xi = 0,$$

where M represents on a suitable scale its moment of inertia. Under a rigorous mathematical treatment, differential coefficients of higher order will appear, but the terms here given are the most important.

The solution of this differential equation is

$$\xi = \xi_0\, e - \frac{b\,t}{2\,M} \sin(\delta\, t + \eta),$$

where $\frac{2\pi}{\delta}$ is the period of the oscillation and δ is equal to $\sqrt{\frac{c}{M}}$ nearly, if (as is usually the case) b^2 is small compared with $4\,c\,M$.

The oscillations represented by this expression are the free oscillations executed by the dynamo when disturbed by a temporary change of conditions—*e. g.*, if its load be suddenly thrown off, or if, being a generator, it be switched into parallel with its fellows. Dr. Hopkinson showed many years ago that the quantity c is positive—in other words, that if the state of steady motion be disturbed the forces so called into being tend to restore it, or the motion is stable. Since then Kapp and others have worked out the value of c. It is easy to show that, sufficiently nearly for all practical purposes,

$$c = \sqrt{\frac{A^2}{2L}},$$

where $\frac{A\,p}{\sqrt{2}}$ is the open circuit electromotive force of the dynamo ($\sqrt{\text{mean}^2}$) ($2\pi/p$ being the periodic time of the alternations) and L the self-induction of the armature, including therein the armature reaction, and the self-induction of any conductors in series with the armature. Another expression for c, at once deducible from the above, is $c = \sqrt{\frac{E\,i_0}{p}}$, E being the open circuit electromotive force and i_0 the current in the machine when short-circuited and driven at the proper speed.

It is obvious that the importance or otherwise of these free oscillations depends on whether they are damped out or not. It has usually been assumed that b is a positive quantity—*i. e.*, that the oscillations are resisted by a sort of viscous force, and if that is so the oscillations will, of course, rapidly disappear. I have, however, recently shown that under certain circumstances b may be negative, in which case the oscillations will continually increase in amplitude and the running of the dynamo will be unstable, even though b be very small.

Suppose that the dynamo is working as a generator and is driven by a force with a certain periodic variation—*e. g.*, by a reciprocating engine. It is supposed to be coupled in parallel with such a num-

[1] Paper read before the British Association, Southport meeting, September 9 to 15.

ber of other machines that the bus-bar potential is practically constant. The equation of motion then is

$$M\frac{d^2\xi}{dt^2} + b\frac{d\xi}{dt} + c\xi = P\sin\delta' t,$$

where $2\pi/\delta'$ is the period of the variation in the force. The solution of this equation is (leaving out the free oscillations)

$$\xi = \frac{P}{\sqrt{b^2\delta'^2 + (c - M\delta'^2)^2}}\sin(\delta' t - \eta),$$

where

$$\tan\eta = \frac{b\delta'}{c - M\delta'^2}.$$

I shall presently show that in practical cases $b\delta'$ is small compared to c, so that the equation for ξ is, unless c is nearly equal to $M\delta'^2$,

$$\xi = \frac{P}{c - M\delta'^2}\sin\delta' t,$$

$$= \frac{P}{c\left(1 - \frac{\delta'^2}{\delta^2}\right)}\sin\delta' t,$$

where $2\pi/\delta$ represents, as before, the period of the free oscillations. These are the forced oscillations produced by uneven turning moment in the prime mover. Superposed on them there will be the free oscillations already considered.

The possibility of parallel working, or of the working of a synchronous motor, therefore depends on two conditions. First, the quantity b must be positive, so that any free oscillations are damped out within a short time of being set up. Second, the forced oscillations must be of such moderate amplitude as not to interfere with practical working. I will deal first with the last-named condition, as it admits of much simpler treatment than the other.

For an ideal machine, without any flywheel effect at all, δ is infinite, and we have $\xi = \frac{P}{c}\sin\delta' t$. In this case, the phase displacement is always such as to correspond exactly with the torque exerted by the prime mover. Such a machine would run fairly well in parallel with others, simply delivering to the bus-bars at all times exactly the energy given to it by its engine. But now if a flywheel be added, δ becomes finite, and so long as it remains greater than δ', that is, so long as the natural period of the alternator is less than that of the variation in turning moment—the amplitude of the oscillations becomes greater with increase of flywheel until, when $\delta = \delta'$, there is perfect resonance, and the oscillations are only restrained by the viscous damping. Further increase in the flywheel effect results in a continuous diminution of the oscillations. If δ is so far diminished by increasing the flywheel that δ' is several times as large as δ, the formula for ξ becomes

$$\xi = -\frac{P}{c\frac{\delta'^2}{\delta^2}}\sin\delta' t$$

$$= -\frac{P}{M\delta'^2}\sin\delta' t.$$

Now, the practical rule always adopted by designers for working in parallel is that the angular displacement of the machine in a revolution when running unloaded as compared with a uniformly revolving wheel shall not exceed a certain fraction (varying from one one-hundred and forty to one-seventy) of the angular pitch of the poles. If the machine is unloaded the equation of motion is

$$M\frac{d^2\xi}{dt^2}P\sin\delta' t,$$

or

$$\xi = -\frac{P}{M\delta'^2}\sin\delta' t.$$

ξ is the phase-angle of displacement measured in such units that the angle between a pair of adjacent poles (or pitch-angle) is π. The practical rule, therefore, directly limits the angular amount of the forced oscillations, provided that δ' is large compared with δ, or that the natural period of oscillation of the alternator is large compared with the period of variation in turning moment.

Limitation of the angle by which the machine deviates from perfectly uniform rotation is not, however, precisely what is needed. What should be limited is rather the amount of the fluctuation in the rate at which energy is delivered by the machine to the bus-bars. This, since the speed is practically constant, is proportional to the variation of torque—that is, to $c\xi$. Now, c is equal to $\sqrt{\frac{A^2}{2L}}$, and depends upon the electrical properties of the machine. Hence a machine with small self-induction will operate worse in parallel under a given amount of angular displacement than will another of large self-induction, always supposing the above-mentioned condition of long natural period to be fulfilled. Here, therefore, is a sufficient explanation of the wide variation in angular deviation permitted by different designers; what suits one machine will not suit another, and a machine with small self-induction and armature reaction, or what is called a machine with good inherent regulation, must be subject to more stringent rules as regards angular deviation than one with large self-induction.

Another cause which makes a fixed rule as to angular deviation inapplicable to all cases, is the fact that in some designs the natural period of oscillation may not be long, compared with the period of the engine impulses. Should these two periods become even approximately equal—if, for example, δ were anywhere within twenty per cent of δ', then the rule quite ceases to be applicable, and the amount of angular deviation in actual working as a generator bears no fixed relation to, but is much greater than, the same deviation when unloaded. As a matter of fact, in machines as now designed, in which the self-induction and armature reaction are usually sufficient to allow the machine to be short-circuited when partially excited without damage, the natural period of oscillation, even without a flywheel, is usually greater than the period of engine impulse. The latter period, even in a slow-speed engine, will not, as a rule, exceed one-third of a second, while the natural period will be found to be of the order of half a second or more, and very much greater with a heavy flywheel. Probably, therefore, a designer will generally be justified in assuming that the two periods are sufficiently different to ensure that he will get about the same angular deviation when delivering energy to the bus-bars as when the machine is running disconnected. He will, however, have to take account of the change in the rate of flow of energy to which that deviation corresponds on his particular machine, and it is in neglecting that factor that the practical rule seems to be illogical.

We have, so far, considered that particular component of variation in turning moment which is responsible for the major part of the phase displacement when the machine is running disconnected, and which is, accordingly, alone regarded in the practical rule for flywheel effect. That, however, is not in fact the only component of the variations; there will be other components of both longer and shorter period. Take for example the case of a single-cylinder double-acting Körting gas engine running at ninety revolutions. The principal variation in turning moment, and the only one producing any appreciable effect on the phase displacement when running light, will be due to the explosions, and will have a period of one-third of a second. As stated above, the natural period of oscillation of the alternator will probably be much greater than this. But there will also be a variation in turning moment due to the weight of the crank,

with a period the same as that of the revolution of the engine, or two-thirds of a second. Now it is not impossible, with a light flywheel, for the period of oscillation of the alternator to have that value, and if that were so violent hunting would be set up, even though the variation in turning moment due to this cause were too small to produce an appreciable effect on the phase displacement when running light. Only, in this case of a small disturbing force, the approximation of periods must be fairly close to produce serious effects. The ordinary rules as to flywheel effect generally result in the natural period of oscillation being substantially greater than the period of revolution of the engine, but in a somewhat roundabout and accidental way. It seems highly desirable on many grounds to pay more attention than has hitherto been usual to the natural period of oscillation of the alternator when specifying flywheels. The period of oscillation of the governor of the engine should not be lost sight of; this is generally fairly long, and may not impossibly give rise to resonant oscillations.

So far, we have considered the forced oscillations caused by the uneven turning moment of the prime mover in a generator working in parallel with a number of others. A very similar, and equally important problem is that of a synchronous motor or rotary driven from mains in which the potential varies periodically owing to unevenness of rotation in the supply generators. Here, if the motor or rotary had no flywheel effect at all, it would follow the generators precisely in their oscillations, and it is easy to see that if ξ_0 be the maximum phase displacement in the generators and ξ_0' that in the rotary, then

$$\xi_0' = \xi_0 \Big/ \left(1 - \frac{\delta'^2}{\delta^2}\right),$$

where $2\pi/\delta'$ is the period of the variation in the generator, and $2\pi/\delta$ the natural period of oscillation of the rotary. In the case of a rotary, however, it is unusual to have any flywheel, and consequently δ, though usually less than δ', may be sufficiently near it to cause the oscillations of the rotary to exceed in amplitude those of the generator. Furthermore, the danger of actual resonance with the revolution of the engine is in this case very much greater. I came across a case recently of a motor-generator which could not be worked owing to resonance. Its natural period happened to be very nearly equal to that of the revolution of the generator—about two-thirds of a second—and it dropped out of step in a very short time, though the variation of turning moment of the period in question must have been quite small. By altering the field current so as to increase the natural period about twenty-five per cent the forced oscillations disappeared almost completely, showing that the difficulty was entirely due to resonance. This suggests the reflection that it might possibly be better in some cases to put flywheels on the comparatively high-speed rotaries, and allow a small flywheel and a bigger angular deviation in the slow-speed generators.

The question of free oscillations is a very much more complicated and difficult one than that of forced oscillations. The period is, of course, easily determined, but, as already indicated, the importance or otherwise of these oscillations depends almost entirely on the way in which they are damped, or on the sign of the quantity b. If b be positive, the oscillations are damped out and are unimportant. On the other hand, if b be negative, even though very small, the oscillations will continually increase according to an exponential law, and the running of the machine will be impossible as a practical thing. The stability or otherwise, therefore, depends in this case on the sign of a small quantity and may be affected by a very small change in the conditions. I have recently investigated this question, and I have shown that under certain circumstances[1] b may be negative. I will not reproduce the mathematics here, but will merely give the conclusions.

Consider an ideal synchronous motor in which the exciting current is maintained absolutely constant, while the field magnets and the armature core and conductors are so perfectly laminated that no appreciable eddy currents flow therein. I find that the motion of such a motor is unstable or b is negative, provided that $\mathrm{L}\,p > \rho$. Here ρ is the resistance and $\mathrm{L}\,p$ is the reactance of the armature and any conductors in series with it. The actual value of b I find to be

$$-\frac{1}{2}\,\rho\,\mathrm{A}^2\,\frac{\mathrm{L}^2\,p^2 - \rho^2}{(\mathrm{L}^2\,p^2 + \rho^2)^2}.$$

The condition $\mathrm{L}\,p > \rho$ is generally fulfilled, so that an ideal motor such as that described is in general unstable, and all motors have this element of instability. In actual machines, however, there are a number of causes which give rise to real viscous forces, and generally overcome this tendency to instability. Such are the local currents induced in the substance of the armature conductors, and (generally but not always) the "amortisseur" effect of currents induced by the oscillations in the pole-pieces, the field coils, and in any special "amortisseur" coils put there for the purpose. It will be found, on working out the value of b that in machines of modern design and any considerable size, it is insignificant under ordinary conditions of working. In small machines, however, and in large ones on long transmission lines it may be important. I have myself experimented with a small motor, the running of which was actually unstable from this cause.

Of the causes mentioned above as making for stability by producing a viscous damping effect, the most important is that described as giving rise to "amortisseur" action. Consider an ideal motor of the type described in the last paragraph coupled to mains giving constant alternating potential moving steadily and doing external work. For simplicity we may suppose the open-circuit potential of the motor to be equal to that of the mains. The effect of the armature current on the field will be to decrease the induction in the field magnets somewhat and also to distort it, so that the point of maximum induction and zero back electromotive force is displaced backward against the direction of rotation. Suppose, now, that the motor executes oscillations about the position of steady motion. Then the field will experience variations of like period both as regards its magnitude and its distortion. To put the matter in symbols, suppose that $\mathrm{A}\cos\theta$ is the induction linked with armature and field coils in the steady motion (θ being an angle defining the position of the armature). Then in the oscillation which is given by $\xi = \xi_0 \sin \delta\, t$ the induction will be $(\mathrm{A} + a_0' \sin \delta\, t)\cos\theta + b_0' \sin \delta\, t \sin\theta$, the quantities a_0' and b_0' being positive, since when ξ is positive there is a greater total induction and a less displacement of point of maximum induction than when ξ is zero.

Now suppose that the pole-pieces are surrounded by short-circuited copper conductors, and that the pole-faces are covered with copper plates, or have copper conductors threaded through them to form a grid. Then the changes of magnetizing force due to the armature current will cause induced currents to flow in these conductors, and the general effect of the currents will be to somewhat reduce the amplitude of the changes of induction in the pole-pieces, and to cause them to lag rather behind the changes in armature reaction which give rise to them.

[1] Paper read before the Royal Society, June 18, 1903. See the *Electrician* (London), August 7, 1903.

The consequence is that the induction linked with armature and field coils is now

$$\{A + a_0 \sin ('t - \eta)\} \cos \theta + b_0 \sin (\delta t - \zeta) \sin \theta,$$

where a_0 b_0 are (for the motor) positive quantities less than a_0' and b_0' respectively, and η ζ are positive angles which depend upon the resistance of the "amortisseur" conductors and on the armature reaction. Thus, at the time when the armature is passing the position of steady motion ($\xi = 0$), but moving with more than the steady motion velocity, the induction, instead of having its normal value A cos θ, has the value $(A - a_0 \sin \eta) \cos \theta - b_0 \sin \zeta \sin \theta$. In other words, the currents then circulating in the "amortisseur" coils are such as to reduce the magnetization somewhat and to displace the point of maximum induction or zero open-circuit electromotive force rather behind the position which it would occupy in ordinary steady motion. We have now to consider the effect of these changes in the induction on the torque at this moment, since it is the then deviation of the torque from its steady value that determines the value of b.

First, as regards the demagnetization, due to diminution of current in the field coils or to currents in short-circuited windings surrounding the pole-pieces. It is easy to show that the effect of reducing the field current in a synchronous motor may be either to increase or diminish the torque—it depends on the load on the motor. Let β_0 be that component of the current which is in phase with the back electromotive force, and Ap the back electromotive force of the motor, so that the rate of working of the motor is $\frac{1}{2}$ A p β_0. Then a reduction in the field current will result in a reduced torque provided that

$$\beta_0 > \frac{A\, p\, \rho}{L^2 p^2 + \rho^2},$$

where, as before, ρ is the resistance, and L p the reactance of the armature and any conductors in series with it. Similar considerations apply when the dynamo is working as a generator, only in this case the effect of the induced currents when $\xi = 0$ is to increase the magnetization while the sign of β_0 is changed. The general result is that if β_0 be outside the limits $\pm \frac{A\, p\, \rho}{L^2 p^2 + \rho^2}$ the induced currents tend to damp out the oscillations. On the other hand, if β_0 be within these limits, the induced currents tend to increase the oscillations, and under such circumstances damping coils surrounding the pole-pieces are additional causes of instability. In the case of a machine connected direct to bus-bars in parallel with others, these limits for β_0 are very narrow; but in motors or converters on long transmission lines they may be so far apart as to give rise to instability at light loads. There is little doubt that trouble has been experienced from this cause. It was one reason for the instability of the small motor to which I have referred, and the constants of that motor might easily be repeated on a much larger machine if there were considerable self-induction and resistance in circuit with it.

We may now consider shortly the damping effect of solid pole-pieces, copper plates over the pole-faces, or copper bars threaded through the pole-face to form a grid. As already pointed out, the effect of the currents in such conducting bodies at the moment when the motor is in the position of steady motion, but moving with more than the steady motion velocity, is to so distort the field as to move the position of maximum induction somewhat behind that which it occupies in steady motion. This is in effect the same as reducing the phase difference between motor and generators, and it therefore in all cases results in a reduction of the torque of the motor as compared with the normal steady motion torque, or on the balance in retardation of the motor. Hence damping coils of this kind invariably exert a true damping or viscous effect. Moreover, I have worked out the amount of the effect, and find that it is much greater than that due to the variation of current round the pole-pieces. It is these conductors across the face of the pole-pieces that are the really useful "amortisseurs," and by their use it would seem that b can always be made positive and the motion stable.

I do not propose here to go into the actual value of the damping effect produced by these "amortisseur" coils. It has been worked out and the results will shortly be published. One thing, however, may be noted here, and that is, that as the resistance of the coils is diminished, the effect increases to a maximum and then diminishes. It is obvious that if the pole-pieces were surrounded by perfectly conducting coils and faced with perfectly conducting plates there could be no changes of induction produced by an oscillation about steady motion, and, therefore, no damping effect. The point is that the coils diminish the amplitude of the changes of induction produced by armature reaction approximately in proportion to their conductivity, and at the same time give rise to a difference of phase between those changes and their cause. The amount of damping effect is proportional to the amplitude of the changes and to the phase difference. It is therefore possible to increase the conductivity of the coils too far—that is, to such an extent that the diminished amplitude more than compensates the increased phase-difference. Whether this happens in practice I am not prepared to say, as it depends on many elements, such as the period of oscillation, amount of armature reaction, etc., but I am clear that it is not impossible with constants such as one meets with in ordinary designs.

One other point is of interest in connection with "amortisseur" coils. They have been regarded here as a means of making b positive, or of removing that tendency to instability as regards free oscillations which is inherent in all machines. Of their great value for that purpose there can be no doubt whatever. It has often been suggested that they also play an important part in reducing the forced oscillations which were considered in the first section of this paper. My own belief, however, is that their action in that respect is insignificant. Looking back for a moment to the expression for the forced oscillations, damping being taken into account, we found that it was

$$\xi = \frac{P}{\sqrt{b^2 \delta^2 + (c - M \delta'^2)^2}} \sin (\delta' t - \eta),$$

while the free oscillations were

$$\xi = \xi_0\, e^{-\frac{b\, t}{2\, M}} \sin (\delta t + \epsilon).$$

Now, by the courtesy of the Westinghouse company I have been able to observe the free oscillations on a rotary converter fitted with heavy dampers round the poles and across their faces. The design of these coils was the outcome of much experience, and they may probably be taken as giving the most powerful attainable damping effect. I found that if the machine were paralleled when a little out of phase one could hear it make six or eight complete oscillations. There can be no doubt that the ratio of two successive oscillations was much greater than $1/e$. Assuming it to be equal to $1/e$, we readily find that

$$\frac{b}{2M} \cdot \frac{2\pi}{\delta} = 1.$$

Hence in the expression for the forced oscillation

$$b\, \delta' = \frac{\delta . \delta' M}{\pi}.$$

Now I have already pointed out that the effect of the ordinary flywheel rules is to make δ considerably less than δ'. Hence $b^2\, \delta'^2$ is but a very small fraction of $M^2\, \delta'^4$, and unless c is nearly equal to $M\, \delta'^2$—that is unless there be resonance—the forced oscillations are almost unaffected by the damping. If there be resonance we have $\delta' = \delta$ and

$$b\, \delta' = \frac{M\, \delta^2}{\pi} = \frac{c}{\pi}.$$

Hence the amplitude of the forced oscillations is

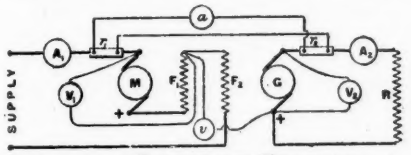
$$\xi = \frac{P}{b\, \delta} = \frac{P\pi}{c}.$$

In other words, in case of resonance the forced oscillations would be about three times as big with this amount of damping as they would if there were no flywheel effect at all and no damping. It would seem, therefore, that damping coils are not of much use for dealing with cases of resonance; a slight variation of the period is a much better solution. To sum the whole matter up, the proper way to deal with forced oscillations is to use the right flywheel, while damping coils must be used for giving stable free oscillations.

A METHOD FOR FINDING THE EFFICIENCY OF SERIES MOTORS.[1]

BY ERNEST WILSON.

The following method has the advantage of great accuracy, and I have found it work well in practice. The figure gives a diagram of connections, in which M and G are two like machines mechanically coupled together, either through or without gearing, according as it is desired to obtain the efficiency of either machine inclusive or exclusive of gearing. In the test M runs as a motor and delivers its energy to G running as a generator. The field coils, F_1 F_2, are placed in series with one another and with the motor armature in order that each machine may be conveniently magnetized to the same degree in any test. The input of the motor is measured on the voltmeter V_1 and ammeter A_1. The generator is loaded on a resistance R, and its output measured on voltmeter V_2 and the ammeter A_2. Let R_1 and R_2 be the ohmic resistances of the motor and generator armatures, respectively, then $V_1A_1 - V_2A_2 = X$ are the total watts dissipated in the system, ex-



METHOD FOR FINDING THE EFFICIENCY OF SERIES MOTORS.

clusive of the generator field coil F_2. Of these $A_1^2 (F_1 + R_1) + A_2^2R_2 = Y$ are the ohmic resistance losses in watts, and $X - Y$ are the watts due to brush, bearing and wind friction, eddy currents and magnetic hysteresis. The machines are equal, and rotate at the same speed. $\frac{X-Y}{2}$ are the watts which can be debited to each machine when calculating efficiency, it being assumed that the brush contact resistance has the same value as when measured with the machines at rest, and that armature reaction does not produce inequality in the watts dissipated by eddy currents and magnetic hysteresis in the two machines. The expressions for the efficiencies are, for the motor, $\frac{X-Y}{2} + V_2A_2 + A_2^2R_2/V_1A_1$, and, for the generator, $V_2A_2 \Big/ \frac{X-Y}{2} + A_2^2R_2 + A_1^2F_2 + V_2A_2$. The above, so far, is a well-known method, and has been described by Mr. Field. The extension here described consists in the addition of two low-resistance shunts r_1 r_2, a milli-voltmeter a, and a voltmeter v. By these instruments the differences $A_1 - A_2$ and $V_1 - V_2$ have been measured as direct quantities. It is easy to show that greater accuracy can be obtain by measuring A_1 and a and using the value $A_1 - a$ instead of A_2, and measuring V_1 and v and using the value $V_1 - v$ instead of V_2. For instance, let $V_1 = 500$, $A_1 = 50$, $V_2 = 450$, $A_2 = 42$, $R_1 = R_2 = F_1 = F_2 = 0.5$ ohm, and let there be a liability for error of one per cent in reading instruments. Then the possible error in the value of $X - Y$, when V_1V_2 A_1A_2 are the measured quantities, is 31.9 per cent, whereas it is 1.9 per cent when V_1 v A_1 a are the measured quantities.

[1] Paper read at the British Association, Southport, 1903.

Annual Meeting of the Indiana Electrical Association.

At a recent annual meeting of the Indiana Electrical Association, the name of the association was changed to the Indiana Public Utilities Association. The by-laws were so changed as to make engineers connected with electrical apparatus in any branch, and agents covering Indiana territory for factories located outside of the state, eligible for membership. An initiation fee of three dollars is charged for membership, and the dues are two dollars per annum.

The new officers elected, together with the committees appointed, are as follows:

President, J. H. Harding, Laporte Electric Company; vice-president, H. D. Haring, Western Electric Company, Indianapolis; secretary-treasurer, A. M. Barron, consulting engineer, Indianapolis.

Executive committee—S. E. Gard, superintendent Citizens' Electric Company, Richmond; H. A. Smith, General Electric Company, Indianapolis; H. E. Wells, Buckeye Electric Company, Indianapolis; Carl Seaman, superintendent Citizens' Electric Company, Winchester; E. M. Sherburn, superintendent light and water plants, Knightstown.

Finance committee—H. C. Kimbrough, American District Steam Company, Muncie; H. D. Schrantz, Westinghouse Electric Company, Indianapolis; I. J. Bell, superintendent electric light company, Bedford; C. D. Boyd, General Electric Company, Indianapolis; John G. Bryson, electric light plant, Brazil.

By-laws committee—A. M. Barron, Indianapolis; T. C. McReynolds, Kokomo; J. H. Harding, Laporte.

The office of the secretary of the association is in suite 5, 120 North Pennsylvania street, Indianapolis.

Breakdowns of Electrical Machinery.

The annual report of Mr. Michael Longridge, chief engineer of the Engine, Boiler and Employers' Liability Insurance Company, of London, England, gives some interesting particulars of the nature of the breakdowns occurring to electrical machinery. This company has adopted a system of periodical independent supervision and inspection, and in this way, besides keeping a record of the most usual breakdowns, makes note of many unusual accidents which would not otherwise be reported.

In this report mention is made of a dynamo which was wrecked by a wood screw one inch long that got between one of the magnet poles and the armature. In another case a small screw-driver was plucked out of the hands of an employé as he was passing a machine, was drawn against the armature, and short-circuited it. A two-pole series motor driving a centrifugal pump ran away one afternoon, most likely owing to the pump losing its water. The armature conductors were forced out of the slots in the core by centrifugal force, and the armature jammed so tightly between the pole-pieces that it could only be got out by driving out the spindle with a sledge hammer and prying out the core-plates a few at a time. The armature of a small shunt-wound dynamo, used for charging a storage battery, was short-circuited by failure of the insulation. The dynamo stood close to a door leading to the battery room, and the fumes from the battery destroyed a cotton covering of the conductors. A motor was short-circuited due to the disintegration of the insulating cardboard disc which was used to cover the end of the core. This had been three-sixteenths inch thick, but crumbled away and allowed the core-plates to get loose and cut through the insulation of the conductors. The shaft of a two-horse-power enclosed-type motor, three and one-half years old, running at 1,800 revolutions, broke. On examination it was found that a deep V-groove had been worn in the shaft by the brass oiling ring.

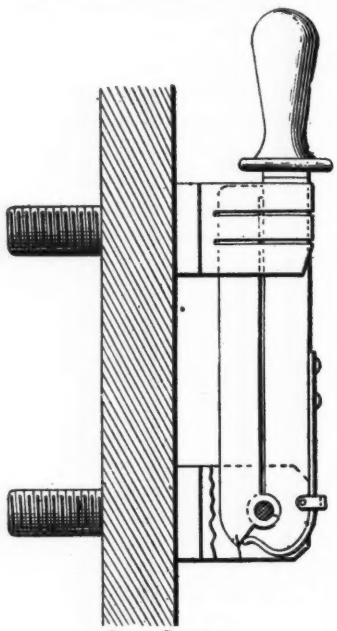
In addition to these exceptional cases, breakdowns were reported from more frequently noted causes and from defective or incorrect wiring.

World's Fair and the Technical Press.

The interest which the electrical department of the Louisiana Purchase Exposition has awakened among the electricians of Europe, is well attested by the attention paid to it during the last three months, by the leading technical publications from Norway to the Mediterranean. All the magazines and other periodicals devoted to electric industries have presented pictures of the Electricity Palace and the Machinery Palace and have commented approvingly on the details of the great preparations made for an unprecedented display of electric exhibits at St. Louis.

Electrical Patents.

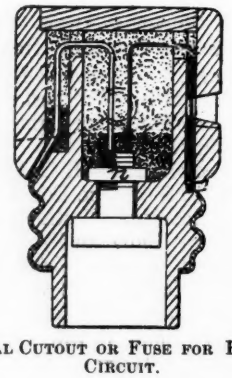
The General Electric Company is the assignee of a new snap switch invented by Robert H. Read, of Schenectady, N. Y. Heretofore switches of this type have been made with two movable members or plates pivoted on a common axis and connected by a spring in such a manner that when one member is moved it puts a tension on the spring, so that presently either by the increased spring tension or



SNAP SWITCH.

by abutting stops on the two members, the second member is forced out of the clip, whereupon the recoil of the spring breaks the circuit so quickly that no arc of any consequence can form. In this kind of switch the tension of the spring increases regularly from the time the first member is started out of the clip until the second member begins to move. It is not really necessary to put the spring under tension, at least, to any effective degree, until after the first member has cleared the clip. The patented construction, therefore, comprises a switch having a plurality of blades connected by a spring, the spring being such that one blade can have a certain amount of free or but slightly restrained angular movement before the spring is put under any appreciable tension. The hinge and contact clips are of ordinary construction and the switch preferably comprises two plates mounted on the same pin in the hinge-clip, and both closing into the jaws of the contact clip. On one of the blades is secured a leaf spring, whose free end extends adjacent to a lug or shoulder on the other blade. In one form of the invention the spring does not touch the lug when both blades are closed and in another form shown in the patent the spring does touch the lug, but is not normally under effective tension. In the first case, the outer blade can be swung out of the contact clip before the spring strikes the lug, after which by the continued movement of the blade the spring gradually stores tension until it is strong enough to snap the inner blade out of the clip. In the second form the tension of the spring increases but slightly, when the outer blade is swung out of the clip, but at this point the spring seats against a stop such as a stirrup carried by the outer blade and its effective length is therefore so much shortened that its tension rapidly increases and soon snaps the inner blade out of the clip.

A patent recently issued and assigned to the Siemens & Halske Electric Company, of Chicago, Ill., is the thermal fuse for electric circuits and is invented by Rudolph Hundhausen, residing in Germany. The inventor explains that it has been customary in employing electric fuses, especially in connection with high-potential circuits, to enclose the terminal portions of the fuse wires in cement, gypsum, or some other self-hardening insulating material, leaving the remainder of the wire exposed. Upon a rupture of a fuse, due to an overload or short-circuit, explosions frequently occur which scatter fine metallic particles and result in flames, which tend to maintain a short-circuit between the terminals of the



THERMAL CUTOUT OR FUSE FOR ELECTRIC CIRCUIT.

looped fuse, and which may short-circuit adjacent conductors. In order to decrease the force of the explosion and the consequent danger, the patented construction embraces a fuse plug having concentric terminals, and so constructed that upon a rupture of the fuse the talc or talcum powder, surrounding the ruptured portion of the fuse wire, will readily absorb the gases and metallic vapors resulting from the melting of the fuses. The plug comprises a hollow cylinder having an exterior metallic terminal threaded thereon and a centre metallic terminal located in a recess formed in the inner end thereof, the main fuse wire and the supplemental or indicator fuse wire being extended through the plug. One end of the main fuse is soldered to the exterior terminal, while its other end is soldered to a threaded extension of the central terminal. This threaded extension of the central terminal is passed through the bottom of the shell and is secured in place by suitable means? Both fuses are preferably looped with suitable division walls interposed, and the terminal parts of said fuses are preferably embedded in gypsum or any suitable cement, while their middle portions are embedded in talcum powder or other suitable material capable of absorbing the metallic vapor when the fuses are blown. The partition walls serve to reenforce the powder and to prevent the vapor from passing from one end of each fuse to the other. The wall of the casing is reduced in strength and thickness at one or more places, so that the shell will not be ruptured except at such places when an explosion follows the blowing of the fuses. The supplemental fuse is so constructed that it can not possibly burn before or at the same time the main fuse is blown. This result is accomplished by so constructing the supplemental fuse that an abnormal flow of current in the protected circuit that would cause a rupture of the main fuse when divided between the same and the supplemental fuse would not cause a rupture of the supplemental fuse if the path closed by the main fuse were left intact, or, in other words, the same proportion of this abnormal current initially flowing through the supplemental fuse would not in itself be sufficient to burn the same, so that the supplemental fuse can not possibly burn until the main fuse is blown. The supplemental fuse is designed to serve as an indicating means, whereby the working condition of the main fuse may be determined, and in order to permit the supplemental fuse to be observed, the same is preferably located opposite an opening in the wall of the fuse casing, a small portion of the gypsum or cement being removed from the space between the supplemental fuse and the opening.

A patent just issued to Ludwig Gutmann, of Peoria, and Robert C. Lanphier, of Springfield, Ill., and assigned by them to Sangamo Electric Company, a corporation of Illinois, discloses several important features in electric meters of that type, wherein an armature in the form of a disc or plate of copper is contained in a sealed chamber, and rotates in a gap

in a magnetic circuit, the current being conveyed to the disc or plate by means of a conducting liquid, as, for instance, mercury, in which the disc is immersed. The patented features relate particularly to means for transferring motion from the armature to external devices, such, for instance, as an indicating or recording device when the instrument is used as a meter or gauge of electrical energy. This feature of the invention includes novel means for converting the rotary movement of the armature into an oscillatory

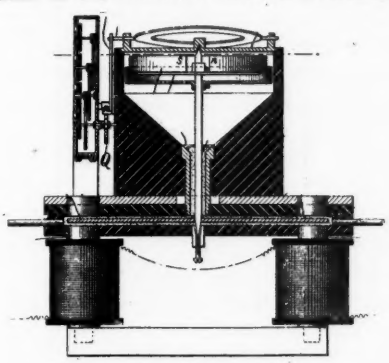


FIG. 1.—NEW FORM OF METER.

movement of the externally operated device, this end being attained by producing a magnetic field rotating synchronously with the enclosed armature and means for causing said magnetic field at opposite sides of its path of rotation to operate upon the oscillatory external armature. Another of the emphasized features relates to means for shielding the magnet of the external device from the magnetic lines of force in the field magnet of the motor portion of the meter. Within a shallow circular chamber of a circular

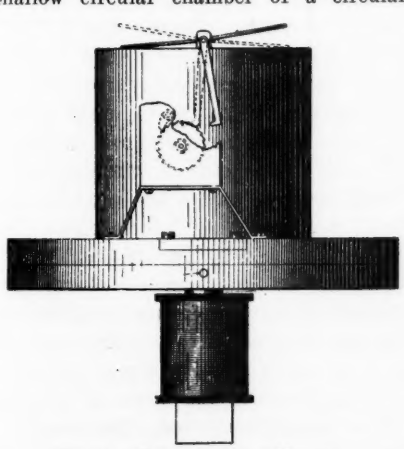


FIG. 2.—NEW FORM OF METER.

casing lined with insulation rotates a copper disc constituting the armature of the motor portion of the device. This armature is mounted on a shaft having a lower bearing in the bottom of the casing and an upper bearing in the cover or head set into the upper end of a hollow block, which encloses the rotating parts of the instrument. This block is of insulation and has a restricted shaft-opening, into which rises the mercury from the armature chamber. It is alleged that this arrangement serves to remove the weight of the rotating element from the lower bearing and to allow free rotation without friction. The field magnet of the motor has its poles embedded in the lower wall of the casing in a manner to make a fluid-tight joint and to be in close proximity to the armature at diametrically opposite points of the edge thereof. Electrical terminals make connection with the body of mercury in which the armature rotates, and the current passes from one to the other, the circuit including the mercury and disc in series. An iron plate is embedded in the top of the casing and has projections which extend down into close proximity to the upper face of the disc immediately opposite the poles of the field magnet, so that the disc or armature will rotate in narrow gaps, through which the magnetic flux of the single magnetic circuit passes from one pole of the field magnet to and through the iron plate and back to the opposite pole of the magnet. This plate also serves to cut off the magnetic lines of the field magnet from certain other parts, particularly a second magnet, designed to assist in the operation of the external device. At the upper end of the shaft carrying the armature is secured an actuating magnet in the form of a ring, whose continuity is interrupted by a narrow gap defining spaced poles, the magnetic flux between which serves to create the magnet field by the rotation of which the external armature is actuated. This ring or magnet rotates immediately beneath the cover of the casing and above said cover is mounted one or more oscillatory armatures, which, together with the operating magnet, are shielded from the magnetic field of the motor by an iron or other magnetic shield fastened to the shaft. A complete rotation of the magnetic field at the top of the shaft will cause a complete oscillatory movement of the oscillatory armature. From this armature motion is communicated to a register-train by means of a lever fastened thereto and carrying at its lower end a pawl operating upon the prime wheel of the register mechanism in an obvious manner.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

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Louis Milton Zapp, Indianapolis, Ind.

Reviews of Current Engineering and Scientific Literature.

The Boehm Train Lighting System.

In this section of the series of articles on train lighting by Herr R. Goutze, the Boehm system is taken up. In this system a generator is driven from the car axle, so that it is possible to equip each car, though this is not contemplated; rather, it is thought better to install a larger generator on one car which will be sufficient to supply the lights and charge the batteries for a number of cars. The generator is driven from the axle by means of intermediate friction rolls. On the axle is placed a driving wheel, and below it is mounted a generator with a suitable pulley on the shaft. Between the two, and mounted on rocking arms, are two friction rolls, which are pressed in from each side by a spring. The tension of this spring can be altered at will and is regulated by a controlling magnet. The winding of the magnet is connected across the generator terminals. Its pull then varies with the voltage of the system, and as it works in opposition to the spring, the pressure of the two rolls on the driving and driven wheels varies in such a way as to maintain almost constant the speed of the generator and the voltage. The car equipped with the generator has an automatic switch which cuts in and cuts out the generator when the voltage has reached predetermined values. This switch also short-circuits the lamp resistance when the generator is disconnected. The other cars are equipped with a battery and an automatic switch which short-circuits the lamp resistance while the batteries are being charged. The batteries consist of sixteen cells with a capacity of thirty ampere-hours at a three-hour discharge. The generator has an output of two kilowatts and a terminal voltage of forty. It runs at 600 revolutions per minute. The system is used to some extent in Germany.—*Translated and abstracted from the Centrallblatt für Accumulatoren Elementen und Accumobilen Kunde (Gross-Lichterfelde-West), September* 15.

Transmission of Energy to the Sugar Refinery at Cambrai, France.

This is a serial by M. E. J. Brunswick. The author first discusses the general conditions at this plant, which has been using a direct-current system since 1892, but recently it became necessary to add to the electrical plant. The operation of some of the motors in this refinery, which drive the centrifugal drying machines, is peculiar, and it was necessary to study carefully the relative advantages of direct and alternating currents for this work. These machines start and stop very frequently during the day. They are heavy and revolve at a high speed, and the least possible time must be consumed in bringing them up to speed. They must also be stopped quickly, and if accomplished by mechanical brakes, this entails a considerable loss of energy. At first the use of series and compound motors for driving these machines was suggested, as these two motors have a good starting torque; but while the torque at the moment of starting is good, it falls off rapidly as the machine nears its normal speed, which in this case is 1,000 revolutions. This characteristic is undesirable, because the energy required to raise the speed from 900 to 1,000 is far greater than that required to raise the speed from 100 to 200, the kinetic energy being proportional to the square of the speed. These conditions led to the selection of polyphase inductions motors of a peculiar construction, and operated in a particular way. An experimental unit was designed and set up by M. Boucherot at his factory, and from the data secured, motors were designed which require from sixty to seventy-five seconds for starting, run at full speed about fifteen seconds, and require fifteen seconds for braking. The diameter of the centrifugal is 1.25 metres and the kinetic energy at full speed is 110,000 kilogramme-metres. The machines are started 250 times a day. About ten seconds is required for charging the centrifugal and fifteen seconds for emptying it. These motors have a double winding on the rotor; one but slightly embedded in the surface of the core, the other deeply embedded. The outer has a high resistance, and the inner a high inductance. The effect of these two windings is to give the motor a flat torque characteristic. In addition, the motor is started on three frequencies—twenty-one, thirty-five and fifty cycles per second, respectively. In this way the starting current is kept within limits, the loss of energy in starting is reduced from what it would be with a higher frequency, and braking is effected by throwing the motor, when running at full speed, first on the circuit having a frequency of thirty-five and then to the lower one. The machine is thus brought to rest quickly, and energy which would otherwise be lost in mechanical braking is returned to the circuit. The other appliances of the installation are also described in detail.—*Translated and abstracted from l'Electricien (Paris), August* 8 *and* 22, *and September* 5 *and* 19.

Motive Power for Coal-Cutting Machinery.

In a full report of the committee appointed by the North of England Institute of Mining and Mechanical Engineers to examine into mechanical coal-cutting is given an interesting discussion of the use of compressed air and electricity as the motive powers. As regards compressed air, there have been improvements in machinery, by means of which the output has been increased and the supply regulated This power is comparatively simple when placed in the hands of any experienced workman. It is readily adaptable to all power purposes and comparatively free from injury to the machines worked by it in wet or damp pits. On the other hand, the greater efficiency of electricity and the simplicity and low cost at which it can be conveyed from the surface to the face, have led to its increased introduction for power purposes. For coal-cutting its use is extending rapidly. The conditions under which electric cutters operate are peculiarly severe. There is heavy vibration and the load changes greatly and suddenly. The presence of iron pyrites and ironstone-nodules in the stratum cut at times blocks the machinery and causes an increased rush of current which, if it continues for more than a few minutes, may cause overheating and a breakdown. To avoid this the close attention and ready judgment of the man in charge are needed. Bar and chain machines are not likely to become jammed. They consume less power and therefore are not so liable to break down in this way. It is wiser not to let an electric coal-cutter run continuously for a long time, as the temperature rise may cause trouble. Three-phase induction motors have been applied successfully to both the disc and bar types. The difficulty of their low starting torque has been overcome by a mechanical contrivance which allows the motor to make a few revolutions before engaging the disc or bar. In one English mine these motors have been used for more than a year. The three-phase motors have one disadvantage over the direct-current motors, in that they are higher and can

not be used as conveniently in low seams. Electric cutters, owing to the rotary motion in place of the reciprocating, are not subject to such heavy mechanical strains as compressed-air machines. The face connections or trailing cables are handier than compressed-air hose. As regards the capital expenditure, there does not appear to be a large difference between the first cost of a compressed-air and an electrical plant. For deep mines the electrical system is more economical, as it costs less to run cables than pipes.—*Abstracted from the North of England Mining and Mechanical Engineers (Newcastle-upon-Tyne), September.*

The Musical Arc.

This is a communication from Mr. W. Duddell, and draws attention to what the author believes actually determines the pitch of the note in the musical arc. In his original paper an equation was given for the periodic time of the circuit which neglected the resistance, as this was specifically assumed to be negligible. Some misconception has arisen on the subject, as in actual experiment the resistance is not usually sufficiently low to be neglected. Under this condition the complete formula for the periodic time is:

$$T = \frac{2\pi}{\sqrt{\frac{1}{L F} - \frac{R^2}{4 L^2}}}.$$

The resistance here includes that of the arc itself, and this depends, among other things, on the arc length and the current. Consequently, the pitch of the note will depend on the arc length and the current, unless the term, $R^2/4 L^2$, is made negligibly small compared with 1 LF. When small capacities are used the resistance of the oscillatory circuit may be high. Although the pitch of the note depends upon the resistance, the author does not think that this fact may be made use of in measuring the resistance of the arc. He has found by experiment that it is possible, by using sufficiently high-frequency alternating currents, not to alter the conditions of the arc. Then each increase in current is accompanied by an increase in potential difference, but it is impossible for the arc itself to maintain oscillations of this high frequency owing to the fact that then there is no supply of energy to the oscillating circuit. This leads to the important question of obtaining very high-frequency currents by this method. The author has tried this with many conductors, such as gases, vapors, electrolytes and for various kinds of carbon, and has found that ordinary solid carbon can be used to convert direct current into alternating current, giving a frequency of 1,000, but not of 100,000. From these experiments he believes that some of the statements which have been published as to the high frequencies obtained with the carbon arc are erroneous.—*Abstracted from the Electrician (London), September 18.*

Electromechanical Compounding of Generators.

In compounding a generator, regulation may be effected directly or indirectly. In the first method regulation is brought about by a change in that factor which it is desired to have remain constant. Indirect compounding is where regulation is effected through some other factor. A new system of compounding of the second class has been developed by M. J. L. Routin, which is applicable to both direct-current and alternating-current generators. The system is applied to a generator unit by changing the field current of the generator and the steam admission to the engine. To accomplish this a compound solenoid, one winding of which is in series with the generator field and the other with the external load, forms the regulating device. This solenoid acts upon a weighted movable core, the motion of this core changing the resistance in the field circuit and operating a valve in the steam pipe. The windings of the solenoid act in opposition, and under normal conditions the current through the coil in series with the field of the generator exerts a greater influence upon the movable core than the series windings. Supposing the system to be in equilibrium, a change of load causes a greater current to flow through the series winding of the solenoid, thereby decreasing its effective pull upon the core. This allows the latter to descend, reducing the resistance of the field circuit and admitting more steam to the engine. This action goes on until equilibrim is again reached. When the external circuit is open, the solenoid is drawn up completely and steam shut off from the engine. On short-circuiting the abnormal current passing through the series turns of the solenoid overpowers the shunt winding, with the result that the core is again drawn up and the generator shut down. To apply this system to alternators the compound solenoid is replaced by an induction motor, the rotor of which oscillates, but does not revolve. Changes in load on the generator shift the rotor of the regulator through an angle and bring the voltage of the generator to the desired value.—*Translated and abstracted from l'Industrie Electrique (Paris), September 10.*

The Generating Sets for the New Electricity Works of the Manchester Corporation, England.

The city of Manchester is at present equipping several large municipal light and power stations. For one of these stations—that on Stuart street—two vertical, triple-expansion, four-cylinder crank engines are now being installed. These are designed for 190 pounds pressure per square inch at the stop-cock. The steam is to be superheated to a temperature of 500 degrees Fahrenheit, and jet condensers giving a vacuum of twenty-seven inches are being installed. The normal output of each engine is 6,000 indicated-horse-power at seventy-five revolutions, and an emergency output of 6,500 indicated-horse-power for two hours. In running non-condensing the output will be 5,000 indicated-horse-power. The engines were constructed by the Walls End Slipway and Engineering Company. They are mounted on a cast-iron bedplate of box pattern. The corresponding alternator is mounted on independent bedplates with a main bearing on each side. This engine is fitted with two governors driven from the crank shaft through positive gear. One governor controls the speed within two per cent from the mean between no load and full load, with a momentary run up of five per cent when the load is thrown off. Provision is made for adjusting the speed within a range of five per cent up or down by hand. The second governor is provided to prevent excessive speed being attained in case of accident. The flywheel is mounted on the low-pressure end of the crank shaft and is designed to give angular variation in one revolution, not exceeding one in 300. The engine is provided with forced lubrication throughout at a pressure of fifty pounds per square inch, the oil pumps being direct driven from the shaft. Electrically driven oil pumps are provided between the oil separator and the main engine oil tank. Electrically driven barring gear is provided for turning the engine. The guaranteed efficiency is at least ninety-one per cent, and the steam consumption is not to exceed eleven pounds per indicated horse-power-hour, condensing, or eighteen pounds, non-condensing. The generators to be driven by these engines were built in the works of the Allgemeine Electricitäts Gesellschaft, of Berlin, and were described in the ELECTRICAL REVIEW of September 12. —*Abstracted from the Electrical Review (London), September 18.*

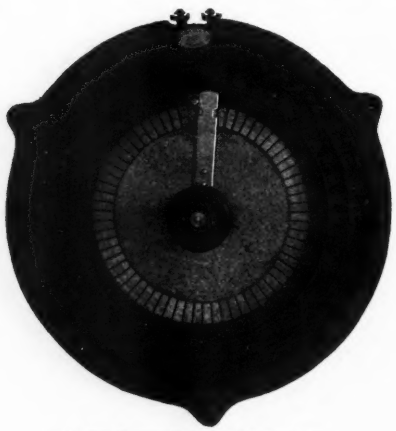
INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

A New Type of Field Regulator.

The Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., has recently placed upon the market a new type of field regulator, an illustration of which is shown herewith. This apparatus is the result of several years of careful study, experiment and test, and it is claimed that in its construction is eliminated various objectionable features which exist to a greater or less extent in some types of field regulators now on the market.

The apparatus consists of a base of insulating material, to which is attached the resistance wire contacts and lever, the whole being carried by a japanned iron casing, which not only gives the instrument a handsome finish, but prevents the possibility of direct contact with the heat-radiating portion of the rheostat. No enamel or similar material is used in the construction, and the resistance material itself can not possibly disintegrate through misuse. It is claimed that grounding is impossible on account of the insulating base, and the compound by which the various current carrying parts are attached thereto is of such nature as to become practically part of the base when the apparatus itself is complete. This substance possesses the qualities of insulation, heat conduction and radiation to a marked degree, and is so little affected by heat that the resistance wire has frequently been run white hot by passing excessive currents through it without in any way causing the compound to deteriorate or separate itself from the base. This ensures the maximum factor of safety for the apparatus, as it makes certain that current will be carried without permanent damage up to the actual burning-out point of the wire itself. The working parts of the apparatus are all amply proportioned for their designed load.



NEW TYPE FIELD OPERATOR.

With these field rheostats for rear of switchboard mounting is furnished a five and one-half-inch hand-wheel, which is made throughout of copper, handsomely polished and lacquered. This new type of hand-wheel is of an entirely novel design. The insulation is of the simplest character, consisting of but a single large piece, and consequently the loosening up of small parts has been entirely done away with.

Test Run of Combination Gasolene-Electric Truck.

In a test run made by one of the Fischer Motor Vehicle Company's five-ton combination gasolene-electric trucks to Morristown, N. J., the following results were obtained:

The truck left the factory at Hoboken at 8.45 A. M. on September 18, running to Jersey City, arriving there at 9.15, where four tons and two hundredweight of sash weights were loaded, the vehicle started on its way to Morristown at 11.05, and arrived there at 6.25 that evening, after having made several stops in the course of the trip, including one hour for dinner. The total time lost on the various stops was one hour and thirty minutes, making the actual running time five hours and fifty minutes. The distance covered was thirty-one and one-half miles, and eighteen gallons of gasolene were consumed.

Taking the total ton-miles traveled for the trip they amount to 129, and with gasolene at twelve and one-quarter cents per gallon—of which eighteen gallons were used—it would figure out one and three-quarter cents per ton-mile for hauling the useful load.

The truck being a five-ton one—if loaded with its maximum—would have used but very little more oil and would have reduced the cost of operating per ton-mile by fully twenty per cent.

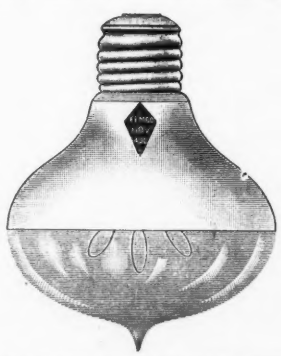
In the course of the trip a number of long hills was encountered, one of them being about a mile long, and in some places these hills were very steep, the grades reaching as high as twelve per cent.

The truck left Morristown on September 19 at 8.25 A. M. and arrived at Hoboken at 1.20 P. M. Several stops, amounting in all to twenty minutes, are to be deducted from this time, which would show the actual running time to be four hours and thirty-five minutes for the return trip. Twelve and one-half gallons of gasolene were consumed.

The Fischer Motor Vehicle Company, Hoboken, N. J., is still busy finishing its orders for the large "buses" for London, and also has secured several orders for five-ton trucks in the United States.

A New Type Reflector Lamp.

The accompanying illustration shows a new type of reflector lamp made by the Franklin Electric Manufacturing Company, of Hartford, Ct. This is the latest addition to the "Femco" line, and the manufacturer claims that it has many good qualities which will recommend the lamp to a particular class of users. Many features of this lamp are unique. The reflecting service is designed with a view of obtaining the maximum effect as a reflector lamp, at the same time making the reflector an integral part of the lamp bulb.



NEW TYPE OF REFLECTOR LAMP.

A candle-power diagram made up from tests on this lamp shows a maximum illuminating effect of slightly over forty candle-power with the same amount of current consumption as required by a regular lamp producing sixteen candle-power. The best materials are used in the manufacture of these reflectors, and the company guarantees the lamp as to voltage, candle-power, efficiency and life. These lamps are furnished with either a crystal or frosted front.

The New York office of the Franklin Electric Manufacturing Company is 815 Havemeyer Building, and the southwestern representative is the Sachs Electric Company, St. Louis, Mo.

The Westinghouse "Turret" System of Electropneumatic Control.

The Westinghouse Air Brake Company and the Westinghouse Electric and Manufacturing Company, under the personal direction of Mr. George Westinghouse, have worked out an electropneumatic system of control differing radically from the drum electropneumatic system which is now well known in the electric railway field. This system has been designated as the "turret" system from the fact that the connections are made and broken by a series of unit switches or

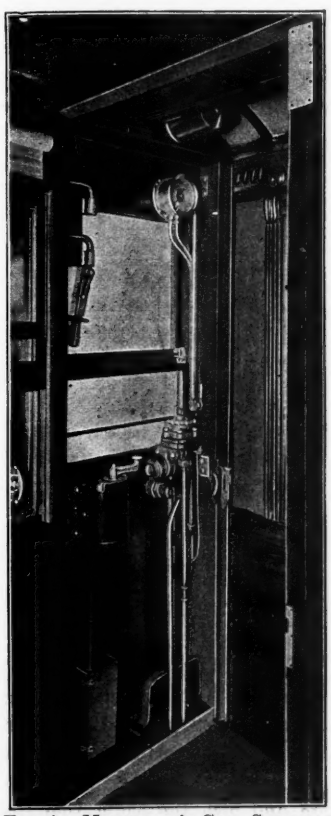


FIG. 1.—MOTORMAN'S CAB, SHOWING AUXILIARY APPARATUS.

breakers grouped in a circular case or turret underneath the car. The movement of the individual switches is through the use of air power controlled by magnets from a battery circuit through a master controller.

The actuating mechanism is not connected directly to the main source of electrical supply, and the connections for the low-voltage control circuits are the only ones which have to be established between the cars of the train. Seven wires are required in the train line battery cable. An important advantage with the use of this separate electrical circuit is that the controlling apparatus can be worked while the main current is cut off, making the control independent of an interruption to current due to the blowing of a fuse, to bad third-rail contact, or other cause. The motors can be reversed and used for braking at any time necessary, even when the rails are dead.

The accompanying illustrations give a good idea of the assembly and detail of the apparatus. Fig. 1 is an illustration of the interior of the motorman's cab. This shows the master controller and operating valve mounted on the inside end panel of the car. In this way the door of the motorman's compartment can be shut against the end panel when the apparatus is not in use, completely enclosing the controlling apparatus. The dimensions of the master controller are seven and one-half inches in height, six inches in width, and four and one-half inches deep, occupying a small amount of room. When the controller is in use the door is swung parallel to the side of the car, providing an enclosed compartment for the motorman. The master controller is mounted so that the controlling handle is thirty-four inches from the floor.

Fig. 2 shows the interior of the master controller. The rotating cylinder of the master controller is made of wood with copper plates and copper spring fingers. This design is very satisfactory, as only fourteen volts are used in the battery or controlling circuit. The reverse cylinder is interlocked with the controller cylinder by a simple device which prevents the movement of the reverse cylinder unless the controller cylinder is at the off position, or the controller cylinder when the reverse cylinder is at either the forward or backward step. The master controller handle is provided with a spring return, making it a "dead man's handle." If the motorman lifts his hand at any time from the controller handle the brakes are automatically applied, unless the reverse handle has first been turned to centre. Another device cuts off the power automatically if the brakes are applied while the power is on. The first result is secured by a connection between the spring return handle and the air brake system, and the second by a connection between the air brake system and a small air cylinder whose piston opens the battery circuit.

A junction box, to which the terminals of the seven battery wires used in operating the turret controller and other car apparatus are led, is placed just below the master controller. This is clearly shown in Fig. 1. This box measures thirteen and one-half inches high by five inches wide by three inches deep.

The batteries for operating the electropneumatic switches of the controlling apparatus consist of two sets of seven cells each, of the Electric Storage Battery Company's type D-5. These are carried under the car in a box twenty-five inches by sixteen and one-half inches by sixteen and one-half inches. The weight complete, with the box, is 300 pounds. Two sets are used to ensure absolute continuity of service, and each is in series with the set of lamps for charging by the line current. Either set is of sufficient capacity to supply all the current required for a day's service and receive sufficient charge during the night while the lights are on. There is no apparatus above the car floor, except the master controller and battery switches, and no power wires are carried above the floor except to one main switch

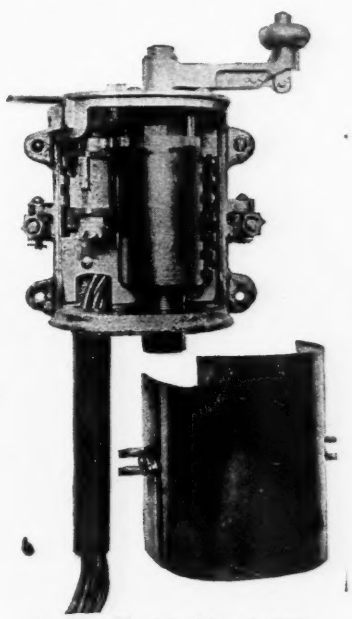


FIG. 2.—MASTER CONTROLLER.

which is located in one of the motorman's compartments.

Fig. 3 is a diagram of the connections. The reverse switch, Fig. 4, is located as near the motor truck as possible, to reduce the length of wire. This is of the usual type, with copper contacts, but is operated by two air cylinders controlled by electropneumatic valves worked from the reverse cylinder of the master controller. Adjoining the reverse switch is the limit switch (Fig. 5) for governing the acceleration. These two switches are usually mounted on opposite sides of the car from the resistance, while the turret controller is located in the centre of the car.

Fig. 6 shows the turret controller open. This is made up of thirteen unit switches arranged radially around an air reservoir and enclosed in a cylindrical casing. The individual switches are operated by pneumatic pistons controlled by electro-

pneumatic valves and operating against a spring pressure of seventy pounds. By utilizing air pressure operating against a spring to control the individual switches, all possibility of welding or sticking of the contact surfaces is eliminated. As an additional precaution, the switch

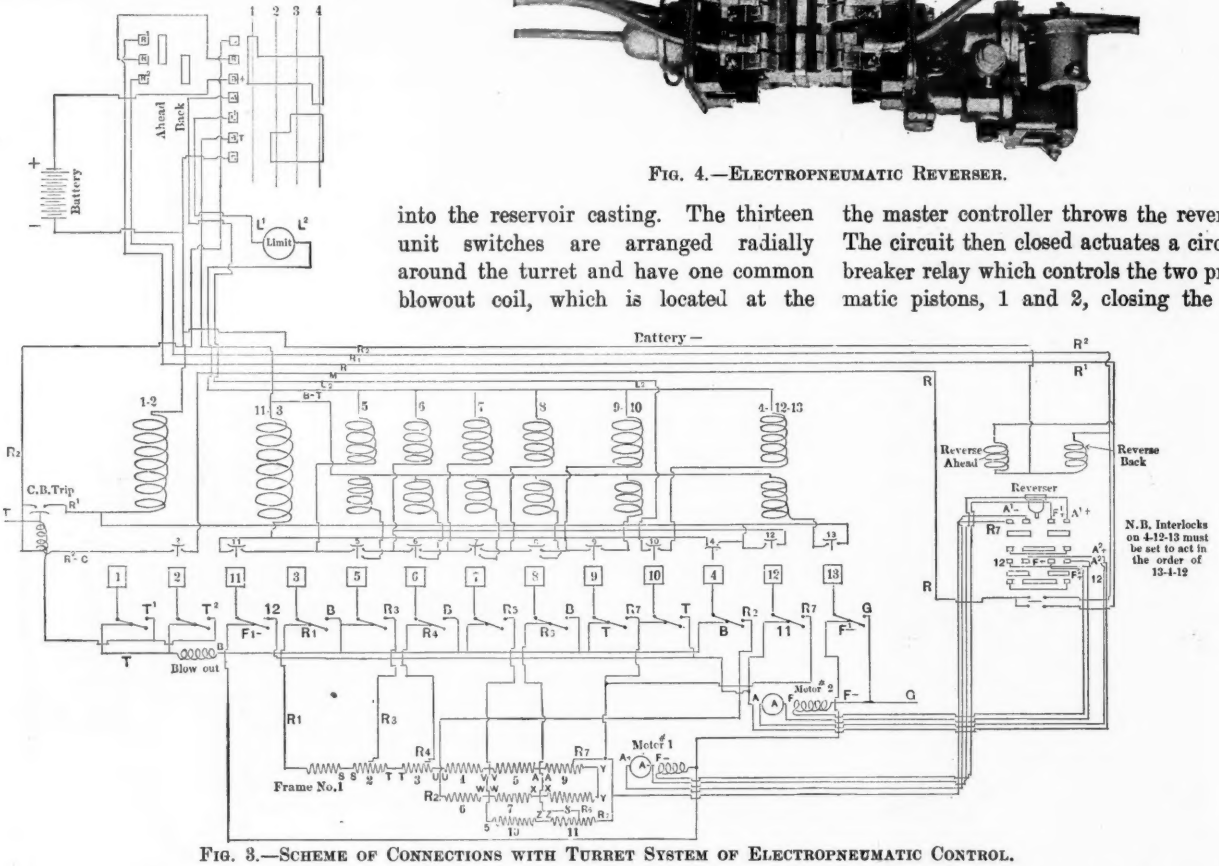


FIG. 3.—SCHEME OF CONNECTIONS WITH TURRET SYSTEM OF ELECTROPNEUMATIC CONTROL.

finger levers are flexible, so that as they are drawn up by pneumatic pressure, and again as they are released by spring pressure, there is a slight rubbing of the con-

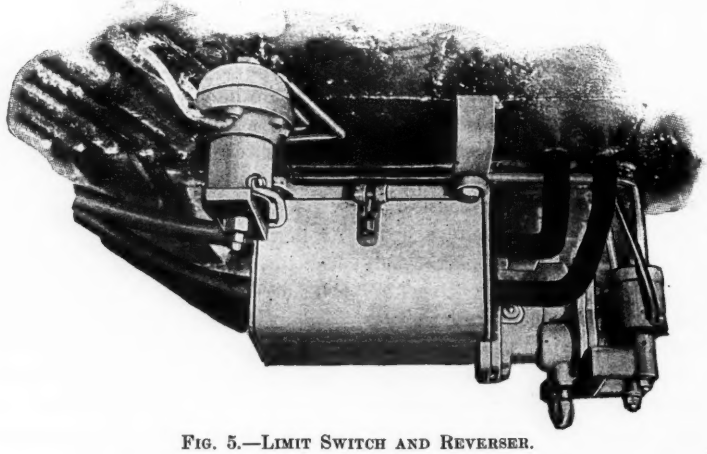


FIG. 5.—LIMIT SWITCH AND REVERSER.

tact surfaces at the moment of engagement or disengagement.

An air reservoir is placed in the centre of the turret, from which the air to the different pneumatic cylinders for the individual switches is supplied. No piping between the cylinders and the reservoir is required, as the cylinders are drilled into the reservoir casting. The thirteen unit switches are arranged radially around the turret and have one common blowout coil, which is located at the centre. The arms of the spider supporting the individual switches form the pole-pieces for the blowout, and as the magnetic field is horizontal, the direction of current in the contactors is arranged so that the arc is always blown out radially. Several of the switches work together, and only eight pneumatic cylinders and controlling valves are required for the thirteen switches.

The operation of the controller is essentially as follows: The first step on

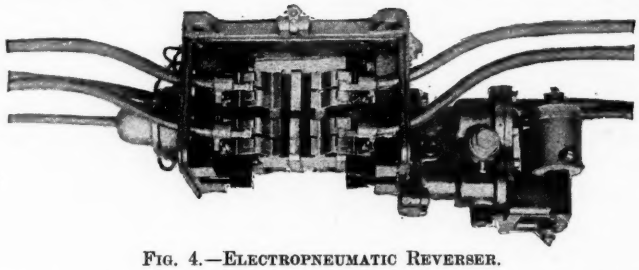


FIG. 4.—ELECTROPNEUMATIC REVERSER.

the master controller throws the reverser. The circuit then closed actuates a circuit-breaker relay which controls the two pneumatic pistons, 1 and 2, closing the cir-cuit-breaker. The second step on the master controller places all the motors in series by actuating the pneumatic cylinders, 11 and 3, which close the series connection and also the connection through the rheostat R-1. The third step cuts out the resistances by closing the circuit through the limit switch and also through the coil No. 5. The action of the switch No. 5 in closing is to establish a circuit through No. 6. When No. 6 closes, a circuit is established through No. 7, and so on up to No. 10, or the full series, thus gradually cutting out the resistances. As each piston drops in closing its switch it also closes a "holding connection" shown directly above each piston, which cuts out the limit switch coil. This prevents the switches, after they have once closed, from opening when the limit switch acts. The limit switch simply prevents the new switch from picking up.

The fourth position throws the motors in parallel. This is accomplished by means of the solenoids, 4, 12 and 13,

which actuate the switches of the same numbers. When these switches start to close they open a circuit on switches 3 and 11, and as soon as they are fully closed they establish a circuit through the holding coil. The current then starts to pick up the resistance coils controlled by switches 6, 7, 8 and 9; No. 6 being the first resistance used in the multiple position. The circuit-breaker trip indicated at the extreme left of the diagram is actuated by the main circuit and is intended to interlock the circuit-breaker, so that in case it opens while the power switch is closed, the breaker can not be reset until the power switch is again opened.

All wires run in "electrobestos" conduit, ensuring a thoroughly fireproof construction. The air for operating the pneumatic switches is taken from the main train line and is first conducted to an auxiliary reservoir through a feed valve to ensure uniform pressure; thence into the reservoir in the centre of the turret. The auxiliary reservoir is provided with a check valve, so that it will retain sufficient air to operate the system in case the main supply should fail. Any number of motor cars can be operated from one master controller by conducting the battery connections from the master controller to any number of turret controllers mounted on any number of motor cars. There are no high-voltage couplings at any point, as the number of battery wires, as mentioned before, is only seven, and the train cable carries only fourteen volts.

The weight of the complete apparatus used per car, as installed on the Manhattan Elevated Railway, New York city, is as follows: Master controller, 695 pounds; reverse switch, 118 pounds; resistances, 490 pounds; circuit-breaker relay, 39 pounds; three junction boxes, 36 pounds; supplementary reservoir, 45 pounds; two master controllers, 39 pounds; storage batteries (fourteen cells), 202 pounds; four seven-point receptacles, 32 pounds; one reducing valve, 15 pounds, making a total of 1,711 pounds.

This system is manufactured by the Westinghouse Air Brake Company, Pittsburg, Pa. The control is now being installed on several cars of the Manhattan division of the Interborough Rapid Transit Railway Company, New York city, and a contract has been closed with the Brooklyn Rapid Transit Company for 264 control equipments of the turret type.

FIG. 6.—TURRET CONTROLLER.

A Large Shipment of Wattmeters.

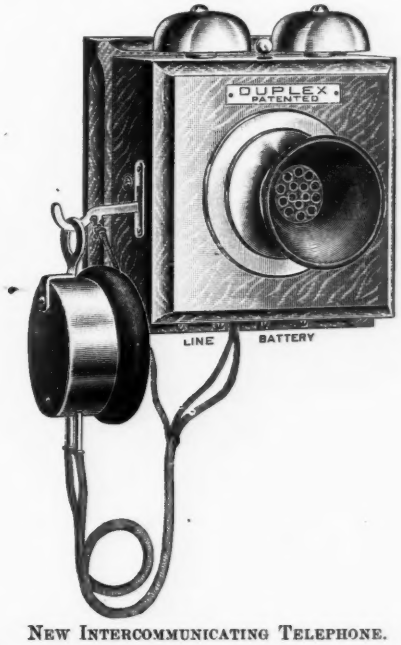
The Stanley Instrument Company, Great Barrington, Mass., has recently made a shipment of glass-enclosed switchboard meters to the New Milford Power Company, New Milford, Ct., for its power stations at Waterbury, Cheshire and New Britain, Ct. The shipment consisted of thirty-six meters, having an aggregate capacity of 16,000 kilowatts. The meters were made up on three sets of marble switchboards to be placed one in each of the substations, respectively, at Waterbury, Cheshire and New Britain, and are to be used for the purpose of registering the current delivered to the electric railway and electric light and power companies in these cities and towns.

This shipment is noteworthy and is probably one of the first of so large an aggregate capacity wherein recording wattmeters are utilized by a transmission company to measure its delivery of current to its customers at the substations at points of delivery. This is in itself an excellent illustration of the progress which is being made in transmission work and the utilization of hydraulically developed electric power for all the various purposes of urban railway service, lighting, and general manufacturing and motor power service.

A New "Duplex" Telephone.

The Connecticut Telephone and Electric Company, Incorporated, of Meridan, Ct., has placed on the market a new type of telephone which has been designated as the "Duplex." About a year ago this company placed its No. 40-30 telephone on the market, which has given satisfaction, and because of this it has been decided to put out the same design built on precisely the same lines, the only difference being in the outward appearance, having double gong bells instead of a monitor pattern bell as used on the original instrument. This arrangement allows the instrument to be put up in a smaller box, making a neater appearance.

The instruments are designed for use on lines of any length over which an ordinary electric bell can be operated. The apparatus is constructed on an entirely new principle, doing away with permanent magnets in the receiver and induction coils in the body of the instrument. They are made up with long-distance transmitters, high-grade "Duplex" battery bell, tempered-steel hook springs, with phosphor-bronze contact springs tipped with pure silver.



NEW INTERCOMMUNICATING TELEPHONE.

The receiver is made of a steel cup, over which is forced a heavily nickeled brass cap, in which is mounted a magnetic coil which is wound with silk-insulated wire. The receiver cord is also of silk, and so attached that, no matter if the receiver is left off the hook, the batteries will not be run down.

These instruments are designed for use with but two on a line, and are used principally from house to stable, from one house to another, or to connect different rooms in a house. They are also used extensively in connection with annunciators for both house and hotel work, in which case they are made up for central battery.

Quick-Break Switches.

The accompanying illustrations show some of the types of switches manufactured by Linton & Southwick, of 60 Hermon street, Worcester, Mass. Fig. 1 shows the "Monarch" quick-break switch,

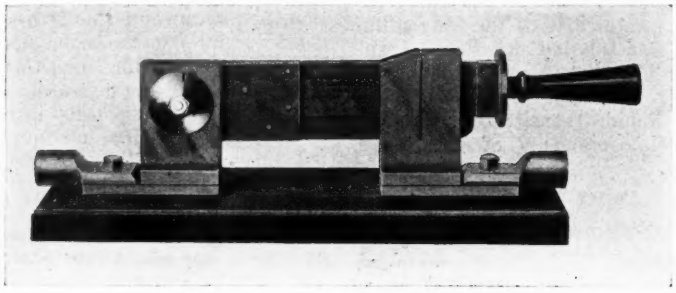


FIG. 1.—QUICK-BREAK SNAP SWITCH.

which is especially designed for stations, isolated plants and railway switchboards. This type of switch is smooth-acting, built in a substantial manner, and makes a neat appearance. The springs to operate the auxiliary knives are entirely concealed and do away with side coil springs and other visible features. These switches are made both single-throw and double-throw, single-pole and double-pole, ranging from 50 to 2,000 amperes at 600 volts. The

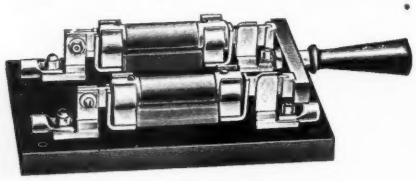


FIG. 2.—FUSE SWITCH

three-pole switches are made both in single-throw and double-throw, from 50 to 2,000 amperes at 600 volts.

Fig. 2 shows the "Ideal" fuse switch manufactured by this company. The special feature of this switch is economy of space. As may be seen from the illustration, the fuse takes the place of a knife, reducing the length of the switch. This switch is made in single, double or

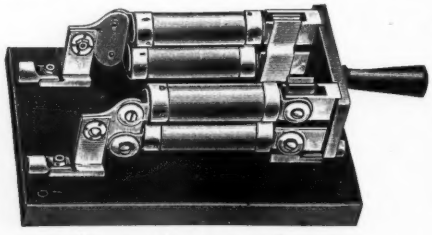


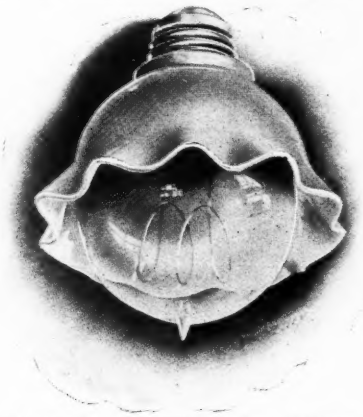
FIG. 3.—EMERGENCY SWITCH.

triple-pole, single and double-throw, from 25 to 500 amperes.

Fig. 3 shows the "Ideal" emergency switch. The object of this switch is to replace a burned-out fuse instantly. The upper fuses carry the current, the lower ones being out of circuit, the fuses on the handle end not touching the clips. When either of the upper fuses blow, the switch is raised so that the lower fuses come into the circuit and make contact. The burned-out fuse can then easily be replaced and the switch thrown back into its original position. These are made in single, double and triple-throw, for 25 to 500 amperes.

Incandescent Lamp Catalogue.

The Standard Electrical Manufacturing Company, Niles, Ohio, has just issued, from the Lakeside Press, a catalogue that



FLUTED SHADE, "WHITE STAR" LAMP.

contains complete data in regard to its line of incandescent lamps. This catalogue has been in the hands of artists for several months, and the lamp cuts have been worked up in the most artistic manner. The catalogue also contains tables and other information valuable to lamp users.

Among the specialties illustrated is the "White Star" lamp, one of which is shown in the accompanying illustration. The company makes a special feature of the quality of illumination from this lamp. The lamp is made with a plain white porcelain shade, or with red or green white-lined shades, and also with the fluted white shade shown in the illustration. The fluted "White Star" lamp is one of the most artistic lamps on the market, and the company states that it is finding a ready sale, both for decorative work and general use.

An Adjustable Desk Telephone Device.

The Chicago Writing Machine Company, 94-96 Wendell street, Chicago, Ill., has placed on the market a device which is known as the "Adjustaphone," and for

FIG. 1.—ADJUSTABLE DESK TELEPHONE.

which the company makes a number of claims of novelty and value. The "Adjustaphone" is a practical device for adapting the desk telephone to any form of desk, and combines a telephone holder or desk bracket for a complete telephone desk set.

The accompanying illustrations will

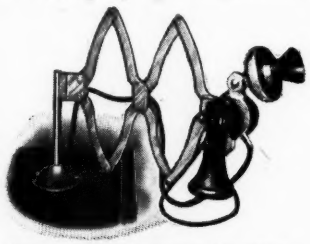


FIG. 2.—THE DOUBLE BRACKET.

show the adaptations of the "Adjustaphone." This can be attached equally well to any vertical or horizontal flat surface. It is movable in any direction without any degree of effort, and as it is securely attached, there is no danger of breakage through a fall or other accident.

The arrangement of the internal mechanism affords compactness, simplicity, durability and efficiency. By

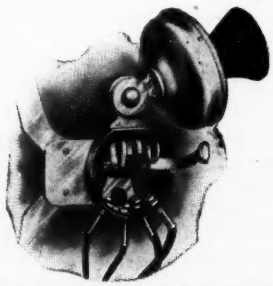


FIG. 3.—INTERIOR MECHANISM.

removing the cover from the cylindrical box containing the internal mechanism, the latter is exposed to full view. The working parts are all easily accessible without removing any of them from the instrument. The contact springs are insulated from the box by a circular

strip of fibre which lines its lower portion. These springs are connected with the cord by terminals passing through metal bushings covered with vulcanized rubber sleeves to provide insulation from the box. The contact springs are held in permanent contact with the metal bushings by means of small nuts which hold them securely in place. The cord terminals, after being inserted through these bushings, are likewise held in place by lock-nuts. A long double curve spring controls the receiver hook, making and breaking contact with smaller curved springs. All of these springs are made of German silver, and platinum points are used for all contacts.

The "Adjustaphone" can be used on any circuit for any class of service, as sufficient contacts are provided for all purposes.

Fig. 1 shows the "Adjustaphone" as attached to the ordinary roll-top desk, with the toggle arms closed up. The arms, as shown in Fig. 1, will extend the "Adjustaphone" about eighteen inches. In Fig. 2 the double length is shown, the arms allowing an extension of twenty-eight inches. Fig. 3 shows the box with cover removed, exposing the working parts.

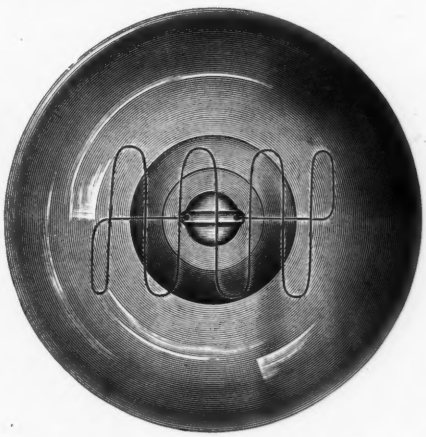
A New Type of Incandescent Lamp.

The Downward Light Electric Company, New York city, has developed a new type of incandescent lamp which possesses a number of features of more than ordinary merit. The accompanying illustrations show the appearance of the lamp and also give a good idea of the design of the filament, together with a comparative set of curves made by the Lamp Testing Bureau, of New York city, showing the distribution of light from the new type of lamp. As will be noticed in the illustration, the filament is so designed that a maximum intensity of illumination is given below the bulb. In doing this the manufacturer has sacrificed horizontal distribution, and where a vertical distribution is desired it is claimed this lamp will be very popular.

Another important feature of this lamp is the tipless bulb which will obviate a great amount of loss due to breakage at the tip. In machine shops and factories, where there is considerable movement at all times and a necessity of having a lamp moved to different points about a piece of work, the advantage of the tipless bulb is obvious.

The accompanying curves show a comparison in the light distribution of several types of lamps. Curve No. 1 is for a sixteen-candle-power double-carbon lamp; curve No. 2 is for a sixteen-candle-power oval anchored lamp; curve No. 3, a sixteen-candle-power double-round-coil lamp; curve No. 4, a sixteen-candle-power flattened double-coil lamp, and curve No. 5 is for a sixteen-candle-power "downward light lamp."

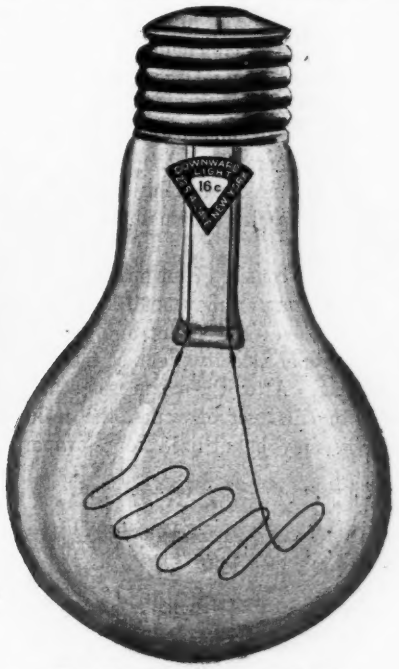
The Downward Light Electric Company is incorporated under the laws of the state of New York with a capital of $100,000, and is composed of a number of experienced old-time lamp salesmen. The Downward Light Electric Company will



TIPLESS BULB AND SPECIAL FILAMENT.

be distinctively a selling company. A factory has been erected and equipped at Cleveland, Ohio, for the manufacture of incandescent lamps by a separate company, and while this is an organization distinct and separate from the Downward Light Electric Company, long-time contracts have been made for almost the entire output of the lamp factory. The Downward Light Electric Company will have a complete lamp-testing laboratory at the factory and will maintain a full corps of inspectors in every department to regulate the output and quality of the finished lamps. The main office of the company will be in New York city, at 225 Fourth avenue. Branch offices will be established in all of the large cities of the United States.

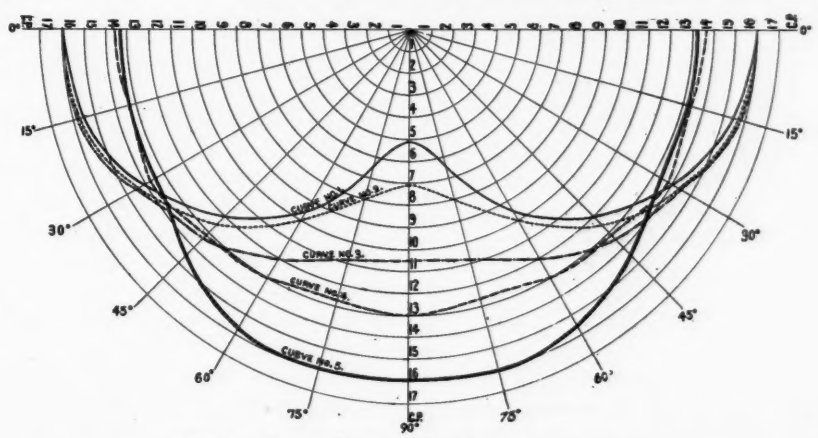
Mr. James C. Wormley, the president of the company, is one of the best-known incandescent lamp salesmen in the United States. Twelve years ago he was connected with the Universal Electric Lamp Company, of Cleveland, Ohio, being associated with this company until its factory was destroyed by fire. At that time he was in charge of the company's head-



NEW TYPE INCANDESCENT LAMP.

quarters at Chicago, Ill. After the destruction of this factory he made a contract with the Bryan-Marsh Company to make lamps under his own label and carried on business in Chicago under the firm name of J. C. Wormley & Company.

At the time the Shelby company was inaugurated, he transferred his contract to it to manufacture lamps for him. In 1896 he sold out his interest to the Shelby company and became a stockholder, shortly after being one of the directors of the company. In 1899 Mr. Wormley opened the New York office of the Shelby company and remained in the capacity of eastern and export manager until September 30, 1903, when he severed his connections with this company to become president and general manager of the Downward Light Electric Company.



COMPARISON CURVES FOR DOWNWARD ILLUMINATION.

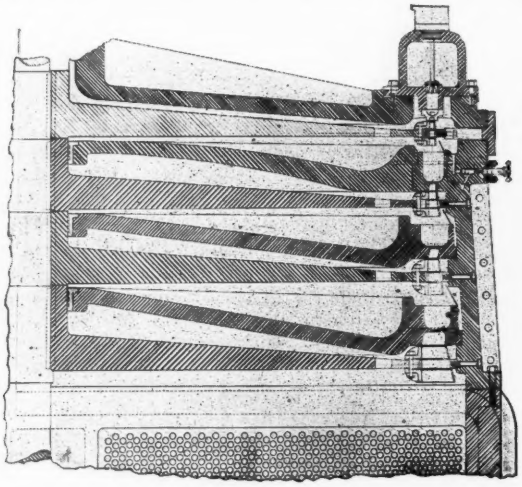
ADVANTAGES OF STEAM TURBINES FOR TEXTILE MILLS.[1]

BY AUSTIN DODGE.

Within the past six years a great impetus has been given to steam engineering by the rapid development of the turbine as a substitute for reciprocating engines.

The advantages are many. To a casual observer of a turbine installation, perhaps the most apparent are the small amount of attention necessary, the small number of moving parts, compactness and simplicity.

All types consist of an opening or nozzle which may or may not be expanding, which receives the steam and directs it at the proper velocity, against the revolving vanes. After the steam is discharged from the first set of vanes, the residual velocity may be utilized to re-evaporate some portion of the moisture inherent to the process of expansion, and enter a second nozzle. This condition ensures expansion in straight lines, preventing eddies in the steam, but necessitates a high vane velocity or a multiplicity of parts.



ASSEMBLY OF 5,000-KILOWATT FOUR-STAGE TURBINE.

Another method is to receive the jet from the revolving vanes in a stationary set of vanes so arranged as to prevent material loss in velocity at the entrance, and redirect the jet at increased velocity by proper expansion into a second and third set of revolving vanes. This method permits a lower bucket velocity, but the tendency for leakage of steam through the clearance spaces is somewhat greater, and the steam jet more irregular the farther it travels in a curved path from one direct guiding nozzle, before reaching another. The buckets revolving nearest the nozzle therefore show the highest efficiency.

With an increased number of stages, the velocity at the end of the nozzle is reduced, as the expansion is less, and a smaller number of wheels per nozzle is necessary to abstract the velocity, reducing the losses mentioned.

The efficiency of action depends largely on the relative velocities of the steam jet and the moving vanes, and the energy required to rotate these vanes under the existing conditions of steam density and moisture.

One of the earliest efficient turbines of practical form was brought out by De Laval, and consists of a single combination of nozzles and a wheel attached to the shaft, carrying the vanes on its periphery. The transformation of pressure into velocity in the nozzle is complex but highly efficient. A high velocity of the moving vanes is essential, but as the angles of entrance and discharge are the same, and as the wheel rotates in a medium which has everywhere the same pressure, there is no troublesome end thrust.

The Parsons machine was brought out shortly before the De Laval and has much lower velocities of steam and vanes, and the process of transforming pressure into work must be repeated many times, entailing a large number of successive revolving rows of vanes with stationary rows of vanes between each.

The Rateau type is similar to the De Laval, except that the combination of nozzles and single wheel is repeated several times, with less expansion during each process than in the earlier turbines. A space is given for the steam discharged from the revolving vanes to utilize its energy in the form of velocity by evaporating part of the moisture, and start the process of fractional abstraction anew in the following nozzle. A single wheel per nozzle, or group of nozzles, affords a minimum change in the direction of the steam jet at high velocity and shortens its opportunity to diverge, before a following nozzle again brings it into line.

The outer clearance is small and the buckets have no outer band like the De Laval, but as steam is admitted only in sections of the periphery, end thrust is eliminated as the pressure on each side of the disc tends to equalize through the empty vanes. The cylindrical clearance space between each intermediate nozzle and revolving element is near the shaft where the clearance can be made a minimum.

TWO INTERMEDIATES FOR SECOND STAGE OF A 500-KILOWATT TURBINE.

Still another type is that brought out in this country by Mr. Charles G. Curtis, which in addition to nozzles delivering steam at high velocity to a single wheel has also stationary vanes which redirect the steam discharged at considerable velocity from the first wheel, due to the relatively low bucket speed, into the second wheel. The velocity of the jet leaving the nozzle is about 2,000 feet per second, while the peripheral speed of the vanes in the Curtis is about 400 feet per second. By this process of fractional

[1] Abstract of a paper presented at the semi-annual meeting of the New England Cotton Manufacturers' Association, Lenox, Mass., September 30 and October 1, 1903.

abstraction the speed of revolving vanes need not be excessive to secure maximum economy, in other words to bring the direction of the jet discharged from the last set of vanes parallel to the shaft. With this high steam velocity only a minimum of revolving vanes are necessary, and they rotate in steam which has a lower density, due to the considerable drop in pressure from one stage to the next. There is a large clearance between outer wall of revolving vanes and the shell, reducing friction due to water of condensation. End thrust is eliminated, as there is abundant opportunity for the pressure to equalize on each side of the revolving discs, and the entrance and discharge angles of the vanes are the same.

In the larger sizes the shaft is vertical and floats on oil under sufficient pressure to balance the weight of the revolving element, which rises a few thousandths of an inch until the clearance is sufficient to permit the discharge of the oil delivered at the centre of the supporting block.

That there is no end thrust in this turbine is shown by the fact that the oil pressure necessary to float the revolving element does not change under any condition of load. This vertical arrangement affords great compactness and greater uniformity of expansion due to heat.

The clearances between stationary and moving parts have proven thoroughly commercial, as shown in several months operation of vertical 500-kilowatt units. In cases in which the oil pressure has failed in the vertical type of this unit during the use of a temporary belt-driven oil pump, there has been no damage to the revolving or stationary vanes. Any contact which may occur is due to the lifting of the revolving element owing to formation of ridges on the step bearing surface. The weight of the revolving element therefore tends to neutralize any tendency to injury. As the vanes are less in width than the metal from which they are cut, nothing more serious happens than a polishing of the solid part of the wheels. Even the step bearing blocks can be faced off and used again. When using the standard direct-driven oil pump a failure of oil supply to the step bearing is highly improbable.

The 500-kilowatt type has two sets of nozzles, each delivering steam to a set of three revolving discs, carrying the vanes, which are machined from the solid disc. Governing is effected by operating a series of valves which controls the admission of steam to the nozzles on the first stage. This ensures a constant velocity in the first stage nozzles, while the pressure in the first stage diminishes with the steam flow until at no load, it is nearly equal to the vacuum in the second stage, a desirable condition, as it reduces the density of the steam in which the first stage wheels rotate, and renders unnecessary adjustment of the valve controlling the second stage nozzles.

The following table embodies approximately the velocities of turbines of 300 kilowatts to 500 kilowatts:

Type.	Rows of Rotating Bucket Rings.	Steam Velocity. Feet per Second.	R. P. M.	Peripheral Speed.	Buckets.
Parsons,	35	400	3,600	200	Inserted.
Rateau,	25	800	2,400	400	Inserted.
Curtis,	8	2,000	1,800	400	Solid.
DeLaval,	1	4,000	20,000	1,200	Inserted.

Each type has its characteristics and the advantages of one over another will depend largely on the cost of construction, reliability and improvement in efficiency.

The amount of capital invested in cotton manufacturing interests has been estimated at over two billion dollars. Let us consider the utility of the steam turbine in increasing the return from this investment. The desirability of the electric drive in textile mills has been clearly established and has already been brought to your attention by Mr. Sidney B. Payne. The advent of the turbine, obviating the necessity of changing reciprocating motion to rotative motion will rapidly increase this application of electricity to your factories.

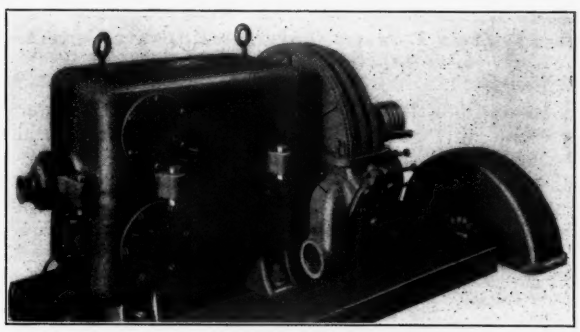
As to first cost of such an installation, a Curtis turbine requires only seven per cent of the floor space taken by a horizontal cross-compound engine of the same capacity, and the cost of foundations is in about the same proportions in favor of the turbine. The weight is from fifteen per cent to twenty-five per cent that of the engine.

There is no wear with a moderate amount of superheat resulting from the action of the steam jet on the vanes, even at a velocity of 2,500 feet per second, as shown by long continued tests.

One of the great advantages of a turbine is due to the entire absence of internal lubrication. Consequently the condensed steam can be returned to the boilers, saving the cost of oil and feed water, often ten per cent the cost of fuel. As no boiler scale is formed while using the same feed water continuously, tube cleaning is unnecessary and the boilers are maintained at the highest efficiency without withdrawal from service.

It is estimated that the saving in attendance charges will average twenty-five per cent on the entire station payroll. A turbine having but one moving part requires no adjustment, unlike a reciprocating engine with a large number of moving parts, which must be carefully inspected at frequent intervals by a skilled engineer. The economy therefore remains constant, which is not true of a reciprocating engine.

One of the principal requirements of textile mills is uniform speed. A turbine has a large amount of stored energy in its revolving parts and is therefore well adapted for work requiring close regulation. Attached are two curves showing the regulation of a twenty-horse-power



FIFTEEN-KILOWATT TRAIN LIGHTING SET.

NEWPORT STATION, NEWPORT-FALL RIVER STREET RAILWAY COMPANY.

turbine and also a 100-horse-power turbine, when full load is suddenly thrown on and as suddenly removed.

The variation in speed of the larger units is within two per cent when the load is varied from no load to full load. Flywheels are not required on any type, as the driving force is always transmitted without angular variation; a desirable condition when generators are operated in parallel.

The absence of internal lubrication permits a high degree of superheat. In the Newport plant the superheat of the turbine has been raised to 250 degree Fahrenheit without increasing the temperature of any part of the revolving wheels or surrounding casing, except the admission valves. The conditions in an engine operating at this high temperature would not be as favorable.

Actual experience in commercial operation has shown that water carried over from the boilers in large quantities does no injury to any part of the turbine, a serious condition when engines are in use.

The first vertical turbine engine to be installed in this country was at Newport, R. I., and has given the following results which have not heretofore been published. Comparison with a Corliss cross-compound condensing engine of similar capacity under the same conditions of pressure and superheat is also made, assuming the engine to have the same full load economy. Few engines of this capacity, even when new, can show as high efficiency at full load. The curves clearly indicate the saving afforded in steam by installing a turbine when operating at light loads and overloads.

The motors required to operate the circulating and air pumps for the condenser are driven from the turbine generator and this power, about twenty kilowatts, is included in the output of the machine. Analysis of the velocities obtained indicates that this result from the first vertical unit will be materially reduced. Lighting, railway and arc load are all carried on the same unit without difficulty. Minor troubles have developed but no more than with every radically new device, and these have in turn been corrected as rapidly as possible under commercial operation.

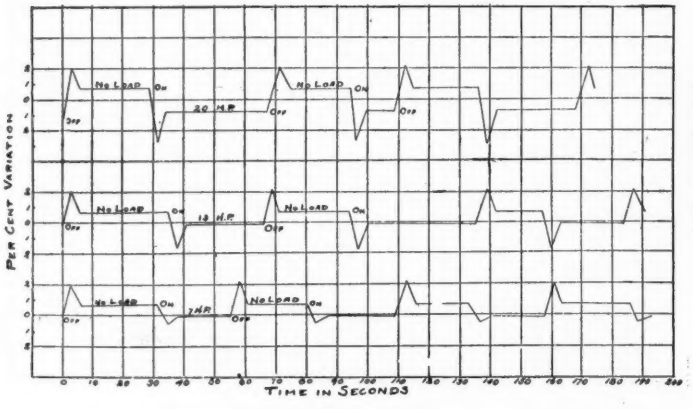
The station is arranged for four turbines, two of which have been put in service.

Similar plants have been installed at Scranton, Pa., Dover, N. H., and within the past year orders have increased to such an extent that 200,000 horse-power of Curtis turbines are under contract. A 600-kilowatt horizontal unit has been in continuous service at Schenectady for two years, operating for two periods of about four weeks each without a single shutdown. A 1,500-kilowatt Curtis unit is in successful operation at Port Huron, Mich., carrying a mixed load of motor power, railway and lighting. This turbine has the standard clearance of 0.03 to 0.05 inch between stationary and moving parts, and can be started cold and brought up to full speed in half an hour. It is easily brought into synchronism with other three-phase generators driven by cross-compound engines. One 800-horse-power Russell and one 500-horse-power Ball, both tandem-compound engines, also one 500-horse-power Westinghouse cross-compound engine, all condensing, have heretofore carried the load, about 750 kilowatts, requiring two 500-horse-power and one 250-horse-power Sterling boilers. With the turbine alone carrying the same load one of the 500-horse-power boilers is cut out.

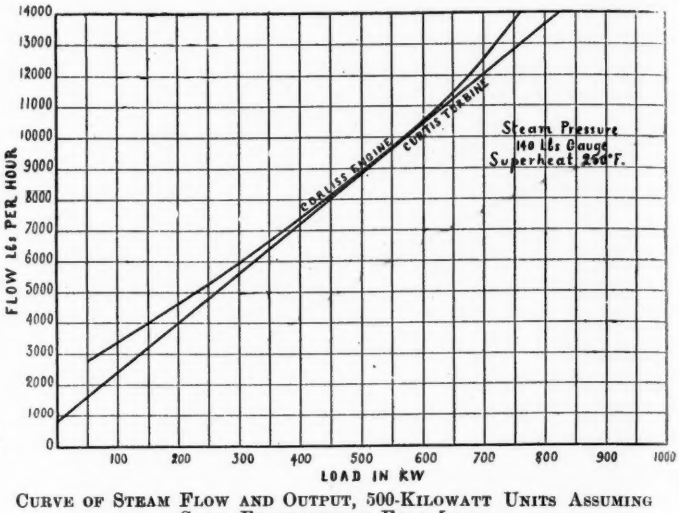
A 5,000-kilowatt Curtis turbine has recently been installed at the Commonwealth station, Chicago, where provision has been made for fourteen similar units. This machine, the first of its size, has been operated continuously for several periods of eight hours each on a water rheostat load of 5,000 kilowatts and will shortly be put in commercial service. On account of water leaks around the condenser tubes, no reliable economy tests have yet been made.

In textile mills the first units to be installed are three 500-kilowatt Curtis turbines at the Lane Cotton Mills, New Orleans, and two similar units at the Fulton Bag and Cotton Mills, Atlanta, Ga.

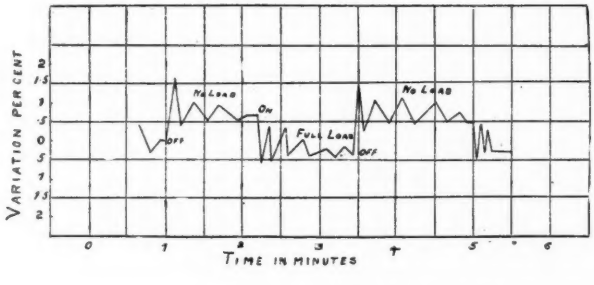
I need not describe these plants further. A sufficient number are already in operation to demonstrate their superiority over recoprocating engines, and the extent of their installation is limited only by capacity for production. The flexibility of the electric drive for textile mills together with still greater adaptability of turbine-driven generators must result in increased capacity at diminished cost.



CURVES SHOWING REGULATION OF TWENTY-HORSE-POWER CURTIS TURBINE, 3,000 REVOLUTIONS PER MINUTE, WITH SUDDEN CHANGES OF LOAD.



CURVE OF STEAM FLOW AND OUTPUT, 500-KILOWATT UNITS ASSUMING SAME EFFICIENCY AT FULL LOAD.



CURVE SHOWING REGULATION OF FIFTY-KILOWATT CURTIS TURBINE, 1,800 REVOLUTIONS PER MINUTE, WITH SUDDEN CHANGES OF LOAD.

CURRENT ELECTRICAL NEWS

DOMESTIC AND EXPORT.

PROJECT FOR MUNICIPAL ELECTRIC LIGHTING AND POWER SYSTEM IN ARGENTINE REPUBLIC—The construction of a municipal electric lighting and power system is projected in Buenos Aires, Argentine Republic, which it is estimated will entail an expenditure of at least $5,000,000.

NEW INDEPENDENT TELEPHONE COMPANY—The Queen City Telephone Company, Cincinnati, Ohio, has been incorporated with a capital of $1,000,000, and it is announced that this capital will eventually be increased to either $4,000,000 or $6,000,000. The company claims to have connections as far east as Philadelphia, west to Kansas City, north to St. Paul, and south to Galveston, and will apply for a franchise.

WASHINGTON, D. C., ELECTRIC NOTES—The electric road building between Washington and Baltimore is making considerable progress, and it is stated that much over half of the grading is completed. The route of this road runs from the boundary line of the District of Columbia east to Bennings, following in a general way the route of the Pennsylvania Railroad to Baltimore. The electric railway company has acquired the steam road to Annapolis, Md., and it will not be necessary to build a new roadway for the proposed branch to that city. It is thought that the road will be in operation next summer. An electric road will also be built between Washington, Vienna and Fairfax, Va., and it is stated that a road of this kind to the great falls of the Potomac river, fourteen miles from Washington, will be begun this fall.

CARBORUNDUM WORKS AT NIAGARA FALLS, ONT., DESTROYED BY FIRE—One of the five furnaces in the furnace and transformer building of the carborundum works at Niagara Falls, Ontario, exploded on Saturday morning, October 3, setting the structure on fire. The power cables leading into the works were cut to enable the firemen to work without danger from the line. The fire was confined, through the efforts of the firemen, to the western building, and the adjoining building, in which were the grinding rooms, storerooms and business offices of the company, was saved. The building contained five furnaces, one large and three small transformers, a switchboard and other electrical equipment, machinery, material, etc. The works at Ontario is a branch of the Carborundum company's works in Niagara Falls, N. Y. Work is already under way clearing away the debris and making preparations for rebuilding and installing the necessary equipment for continuing the business.

NEW MEXICAN TRACTION COMPANY—It is announced that a company known as the Compania Mexicana de Traccion has been recently organized for the purpose of constructing and operating an extensive electric traction system in Mexico City. The company has acquired what are known as the Moylan, Garcia and Requima rights, which permit of the building and working of about 100 miles of road—fifty in the city, and about fifty in the suburbs. The company has also assumed control over the Empresa del Circuito de Banos, a horse road over two miles long, operating between Belvanera and Alberca, in the heart of the Mexican capital. This road will be electrically converted. It is stated that the company has ordered about 1,000 tons of eighty-five-pound girder rails, and is in the market for twenty forty-foot cars which will be equipped with four motors of fifty-six horse-power each. The power-house will have an initial capacity of 2,000 horse-power. The company is incorporated under the laws of Mexico. The directors are James H. Oliver, Julius Bieler, Reuben Miller, Sr., James H. Park and Frank B. Smith, of Pittsburg, Pa. Mr. M. C. McAdoo is president of the company. It is stated that the system will be in active operation inside of eighteen months.

RECENT STATISTICS ON ELECTRIC STREET RAILWAY SYSTEMS—Bulletin No. 3 of the United States census report on street and electric railways shows an unprecedented record in the application of electricity. In 1890 there were 126 companies operating their lines by electricity. They had 1,262 miles of single track. There were fifty-four cable lines and seventy-four steam lines having altogether 1,200 miles of track. In 1902 there were 747 companies operating their lines by electricity, an increase of 492.2 per cent. They were operating over 21,920 miles of track, an increase of 1,637 per cent. The lines operated by horses, cable and steam showed decreases of from fifty to ninety-five per cent, but the total increase in mileage was 178 per cent. There are now twenty-five street railway companies in the United States which have a length of line of more than 100 miles, and 395 companies which have a length of less than ten miles. In all, there are now 987 companies, with a cost of construction of $2,167,634,077 and a capital stock of $1,315,572,960. The increase in the number of passenger cars amounted to 27,785. In 1890 there were 62,237 passengers carried per car, and in 1902, 79,774 passengers per car. In the year 1902 there were 5,871,957,830 passengers who traveled by street and electric railroads. Notwithstanding the fact that over 5,000,000,000 passengers were carried, the report shows that only 265 were killed and 26,690 were injured; 122 employés were killed, and 3,699 injured.

CUBAN ELECTRIC TRACTION COMPANY—An extensive traction and lighting system is to be constructed in the southern part of Cuba, power to be derived from an hydraulic plant which, it is announced, will be one of the largest in that part of the world. The Cienfuegos, Palmira & Cruces Railroad and Electric Power Company has been organized for the purpose of building and operating both systems. The length of the road will be about forty-three miles. Four and one-half miles of track will be constructed in Cienfuegos, and the line will run from that city to Caonao, thence over private right of way to Palmira, Horringuero and Cruces. The track will be standard gauge. Sixty-pound T and girder rails will be employed. The initial rolling stock will consist of four combination cars, thirty-two feet over all, seating twenty-four persons and operated by two fifty-horse-power motors each; four open passenger cars, thirty-five feet eight inches over all, seating sixty passengers and operated by two fifty-horse-power motors each; three closed passenger cars, length twenty-seven feet eight inches over all, seating twenty-four passenger and operated by two twenty-five-horse-power motors each; three eight-bench open cars, twenty-five feet over all; seating forty passengers and operated by two twenty-five-horse-power motors each. Five express cars, measuring twenty-one feet over all and equipped with four fifty-horse-power motors each and having a capacity of twenty tons, will be ordered also; twenty box eight-wheel freight cars, capacity twenty tons; a similar number of eight-wheel flat cars, capacity twenty tons, also sprinkler and repair cars. The company will also generate energy for the purpose of lighting Cienfuegos—about 30,000 inhabitants—and the other towns mentioned, whose population averages about 8,000 people. Power will be derived from the falls of Hababanilla which are known as the Niagara of Cuba. The voltage at which the energy will be transmitted has not yet been determined. The initial capacity of the plant will be 3,000 horse-power.

TELEPHONE AND TELEGRAPH.

CONNELLSVILLE, PA.—The Bell Telephone Company is building a line from Morgantown to Pittsburg.

SPRINGFIELD, MASS.—The Valley Telephone Company will extend its wires to connect the Leverett line with the Dunderland line.

OCILLA, GA.—C. J. O'Farrell has completed the work of installing the new telephone system of the Ocilla Telephone Company.

YONKERS, N. Y.—The Yorktown Telephone Company's stockholders have elected the following directors for the ensuing year: James E. Rice, T. F. Tompkins, Edward E. Kear, E. Munson Frost,

Floyd White, Albert Lee, James N. Strang, James J. Mead and Cornelius Pugsley.

SARATOGA SPRINGS, N. Y.—The Easton & Buskirk Telephone Company will connect with the Hudson River Telephone Company at Greenwich.

CHEYENNE, WYO.—The long-distance telephone line of the Colorado Telephone Company, connecting Portland, Ore., and Denver, Col., has been completed.

CHARLESTON, S. C.—A charter has been granted to the Mt. Pleasant Telephone Company with a capital of $2,500. The company will do business in Mt. Pleasant.

CLARKSBURG, W. VA.—The Consolidated Telephone Company, of Clarksburg and Fairmont, has decided to extend its line to Wheeling, Uniontown and Pittsburg.

DANFORTH, ME.—The Danforth Telephone Company has been incorporated with a capital of $10,000. The officers are V. E. Price, president, and M. L. Porter, treasurer.

DES MOINES, IOWA—The Iowa Telephone Company has let the contract for a new exchange in this city, to cost approximately $37,000. Work is to be completed by January 15.

RICHMOND, VA.—The Lunenburg Telephone Company has been organized at Meherrin with A. M. Bruce as president; E. P. Wallace, vice-president; M. E. Gee, secretary, and E. T. Staples, treasurer.

PITTSBURG, PA.—The officials of the Pittsburg & Allegheny Telephone Company announce that the company's lines between Pittsburg and McKeesport will be in operation in less than sixty days.

RICHMOND, VA.—The Waxhow Telephone Company has been incorporated with a capital of $5,000 to construct lines from Monroe to Waxhow, thence to Charlotte, and to other villages in the vicinity.

SOUTH FRAMINGHAM, MASS.—The New England Telephone and Telegraph Company is laying through Framingham the underground wires which will connect Boston and Worcester with a thorough service.

DECORAH, IOWA—The Summer Telephone Company, capitalized at $30,000, and owning about 150 miles of line, has passed under the control of Victor Stevens, who controls the Standard, Interstate and Dubuque lines.

YORK, NEB.—The York County Independent Telephone Company has connected its lines with those of the Filmore County Independent Company, and also with independent lines at Beaver Crossing, Milford and Friend, Neb.

LEONARDSVILLE, N. Y.—A new telephone line will be constructed in this town, an organization having been formed with E. S. Brand, president; I. A. Crandall, secretary, and A. M. Coon, treasurer. Connections will be made with near-by towns.

FRANKLIN FALLS, N. H.—The Citizens' Telephone Company has been granted a franchise in the town of Meredith and will soon extend its lines to Meredith village. Telephones were put in at Center some time ago, and the service at Tilton is to be increased.

BALTIMORE, MD.—The roofing and exterior work on the new Chesapeake & Potomac Telephone building in this city has been completed and work on the interior of the building has commenced. The cost of the structure, which will be completed by December 1, will be $75,000.

COPPERSTOWN, N. Y.—The Westville Telephone Company has been chartered to build and operate a line from the village of Milford to the village of South Valley. The capital stock is $1,000, and the directors are Frank Green, John Cady, A. Baldwin, K. R. Baldwin, E. Coates, T. Gurney and M. Stilwell.

SHEBOYGAN, WIS.—A. B. Ferdinand, president of the Sheboygan County Telephone and Electric Company, has disposed of his interest and the company will be reorganized. Plans are to be made for giving the public better service, one of the improvements contemplated being the building of conduits for underground work on Main street.

ELECTRIC LIGHTING.

DES MOINES, IA.—At West Liberty extensive improvements are projected to the electric light plant.

INDIANAPOLIS, IND.—Frank Underwood has secured the contract for a new power-house at Hazel Kirk.

LEWISTON, ME.—Important changes and additions are being made at the plant of the Light and Water Company of Rumford.

GRAND HAVEN, MICH.—The board of public works of Grand Haven has about decided to expend $10,000 on the electric plant of the town and to install a day electric service here.

EVANSVILLE, ILL.—The Red Bud city council at its last meeting passed an ordinance granting T. C. Reed a franchise for the purpose of establishing an electric light plant in that city.

COALPORT, PA.—It is stated that Coalport will be lighted by electricity within a short time. Local capitalists have formed a company for installing an electric light plant and are now busy perfecting all arrangements.

HILLSBORO, ILL.—The city council is considering a proposition for the establishment of a municipal electric light plant. At present electric lights are furnished by a private corporation, the contract with whom expired October 1.

GRAND FORKS, N. D.—It is said that the city council of Valley City will offer the electric light plant for sale, as it is not considered a paying proposition for the city. The expenses for the past year were $7,000 in excess of the receipts. The council will offer a twenty-year franchise with the plant.

NORTHFIELD, VT.—J. M. Holland, of New York, a former resident of this town, has bought several Hillside farms, and also the water privileges, in connection with a plan to construct a system to furnish Northfield with water for domestic use, light, manufacturing and other purposes. The estimated cost is from $50,000 to $75,000.

FORT WAYNE, IND.—A company of citizens has published an address to the people offering to build the city an electric light plant which will furnish street lights for $70 a year and charge ten cents a kilowatt for commercial use. The plant is to become the property of the city in ten years, the city paying over to the company the $60,000 which has been raised by taxation for a municipal plant. The persons making the offer are Charles McCulloch, Henry Beadell, J. H. Rahe, Joseph F. Getz, A. Fuelber, Paul E. Wolf, Cooney Bayer and W. O. Gross.

ALBA, TEX.—The Lone Star Lignite, Brick and Light Company was organized here recently. The purpose of the company is to mine coal, make brick and furnish the city of Alba with electric lights. The capital stock of the company is $25,000, divided into as many shares of the par value of $1. The following directors were elected at a meeting of the stockholders: J. E. Gibson, president; A. S. Cain, vice-president; W. R. Goodwin, secretary-treasurer; T. L. Lowrie, manager; Joe McChristian, assistant manager; R. E. Bozeman, attorney.

DECATUR, IND.—The tract of land offered by the Commercial Club to the Springfield & Fort Wayne Traction Company for a power-house site has been turned over to the company and work of erecting the plant will be begun at once. The power-house will be the main station of the line and the conditions on which the site is given the company are that they have the line in operation between here and Fort Wayne by January 1, 1905, and that it be extended from Decatur to the east, west or south county line by January 1, 1906. The main offices are to be located here.

STAMFORD, N. Y.—The Schenevus village board of trustees has granted a franchise to M. E. Baldwin and to any corporation that he may organize to construct a complete electric light system in that village. A contract was also made to light the village streets with forty thirty-candle incandescent lights for $600 per year, the lights to burn every night in the year and the contract to continue for five years. The system of lighting the streets with oil costs the village about $300 per year. A corporation will be organized at once to build and operate the works and a force of men will come from New York city to push the work to completion. The water power at the White mills will be utilized. Extensive repairs to this property have been in progress since Mr. Baldwin purchased it last spring. It is expected that the work will be complete about November 1.

ELECTRICAL SECURITIES.

About once a month for the past half year the statement has been made that prices had at last reached the lowest point possible wthout bringing about financial disaster. Notwithstanding the recurrence of this statement, prices continue to sag and droop, though at the same time there has been a lack of disaster which is remarkable and goes a long way toward establishing a precedent for hopefulness which will always be of value in financial emergencies. One thing is proved without doubt, and that is the inherent stability of a number of securities which have been pounded until they are now far short of their nominal value. During the week the speculative change was radical and of such a nature that it gave evidence that there was considerable support in favor of several industrials which have been mercilessly handled for the past five months. On Monday the market was in a state of semi-panic, and this was followed by a sharp rally which was maintained until, at closing, there was registered a very general advance of from two to five points all along the line.

There is every evidence that the bounteous crop—the product selling at higher figures than for many years—will put into circulation a large amount of buying capital, and this will be a factor in creating a demand for manufactures which will have a vitalizing effect on every industry.

The action of the United States Steel Corporation in offering to take up the securities held by its employés, while in some quarters regarded as an acknowledgment of the defeat of its copartnership plan, is in other quarters regarded as an evidence that the company appreciates the full value of its holdings. The declaration of the regular dividend—which, at the writing, seems entirely probable—will materially help the situation. According to a semi-official statement, steel earnings for the September quarter amount to $35,000,000, which is only a trifle less than for the same period last year.

ELECTRICAL SECURITIES FOR THE WEEK ENDING OCTOBER 3.

New York:	*Closing.*
Brooklyn Rapid Transit	34⅜
Consolidated Gas	172⅞
General Electric	150
Kings County Electric	150
Manhattan Elevated	131¼
Metropolitan Street Railway	106½
New York & New Jersey Telephone	145
Westinghouse Manufacturing Company	166

The annual meeting of the shareholders of the Manhattan Railway Company will be held at the company's office, No. 195 Broadway, Manhattan Borough, New York city, on Wednesday, November 11, at twelve o'clock noon. A board of directors for the ensuing year is to be elected, and three inspectors of election. The transfer books will be closed on Saturday, October 10, at twelve o'clock noon, and will be reopened on November 12, at ten o'clock A. M.

Advices from Pittsburg say that it is understood that Westinghouse earnings for August were the largest in the history of the company, the immense business of August, 1902, having been considerably exceeded, although it had not been expected by the officials of the company.

Application has been made to the New York Stock Exchange to list $625,000 additional capital stock of the Kings County Electric Light and Power Company.

Boston:	*Closing.*
American Telephone and Telegraph	127¼
Edison Electric Illuminating	227
Massachusetts Electric	77½
New England Telephone	124
Western Telephone & Telegraph preferred	80½

Rising seventy per cent of the $21,943,200 American Telephone stock subscription has been paid in, although only twenty per cent was due on September 22, and payments could have been made in twenty per cent installments ending May 6. Fully paid stock will participate in the dividend due in January, 1904. The plan of expenditure of the new stock proceeds is this: For the New England states, $1,535,900; Middle states, $6,603,000; Canada, $500,000; Middle Western states, $2,520,000; Western states, $1,458,450; Southern and Gulf states, $2,709,200; Pacific states, $501,000; for purchase of instruments and construction of long-distance lines, $4,250,000; a total of $20,077,550.

The report of the Edison Illuminating Company for the fiscal year ended June 30, 1903, shows the company's income from the sale of light and power to have been $2,663,733, and the total expense to have been $1,730,456, leaving a net income of $933,277. Other income amounted to $36,578, bringing the total net income up to $969,855. The dividends paid, interest, etc., amounted to $990,175, leaving a deficit for the year of $20,320, as compared with a surplus of $45,843 for the year ending June 30, 1902.

Philadelphia:	*Closing.*
Electric Company of America	8
Electric Storage Battery common	50
Electric Storage Battery preferred	50
Philadelphia Electric	6 1/16
Union Traction	42¾
United Gas Improvement	80

Chicago:	*Closing.*
Chicago Telephone	115
Chicago Edison Light	140
Metropolitan Elevated preferred	52
National Carbon common	18½
National Carbon preferred	88
Union Traction common	4
Union Traction preferred	30

Northwestern Elevated in September handled a daily average of 68,107 passengers, this being an increase of 4,157.

South Side Elevated handled a daily average during September of 81,887 passengers, an increase of 5,315. The report of the company for the year ended June 30, 1903, is as follows: Gross earnings, $1,555,044; expenses, $856,128, leaving net earnings of $698,916, an increase of $50,804 over the preceding year.

ELECTRIC RAILWAYS.

COALGATE, I. T.—Arrangements have been perfected for the construction of the electric road from Coalgate to Lehigh, and work has commenced.

YORK, PA.—Surveys are being made through Elizabeth for a trolley line to connect with the Conestoga Traction Company's line, joining Lancaster and Harrisburg.

NEW YORK, N. Y.—Permission has been granted to the New York & North Shore Railway Company, of Queens, to change its name to the Long Island Electric Railway Company.

PHILADELPHIA, PA.—The Central New Jersey Traction Company has completed its line from Keyport nearly to South Amboy, and expects to have it in operation before fall.

CHICAGO, ILL.—The Chicago & Milwaukee Electric Railway has opened its new westerly branch from Lake Bluff to Libertyville. It is said that the road will be extended to Rockefeller this fall and later to Fox Lake.

TRINIDAD, COL.—The actual work of construction on the Trinidad electric car line has been begun, and the entire line of twelve miles, as well as the electric power and lighting plant to be built by the company, will be completed as quickly as possible.

DOYLESTOWN, PA.—The Philadelphia & Easton trolley road will be completed between Easton and Riegelsville in about two months, when the upper end of the road will be in operation. The remaining twelve miles necessary to complete the road will be built next spring.

WILKINSBURG, PA.—A new car line is being projected which will be known as the Wilkinsburg, East Pittsburg & Turtle Creek Railway, to connect Turtle Creek with Wilkinsburg. The company is capitalized at $30,000, and the promoters are Thomas Gearing, A. J. Kent, M. Douginier and George B. McClellen.

HAVERHILL, MASS.—It is stated that the proposed electric road from Boston to Haverhill will surely be built. It is proposed to run on the Boston & Northern tracks to Maplewood in Malden, and to traverse the Newburyport turnpike for about eleven of the thirty-three to thirty-five miles between Boston and Haverhill.

INDIANAPOLIS, IND.—The Indiana Northern Traction Company has let the contract for the construction of its line from Marion to Wabash. The road is to be in operation next June. From

Wabash it will be extended north, through North Manchester and Silver Lake to Warsaw, and later to Goshen, to connect with the Elkhart and South Bend roads.

NEWPORT NEWS, VA.—The route of the projected Jamestown, Yorktown & Old Point Electric Railway has been determined. The line will have terminals here and at Old Point. The route will be from Jamestown Island to Williamsburg, to Yorktown, to Little Bethel, branching out there to Newport News and also to Old Point. The statement is made that the first car will run into Newport News from Jamestown before January 1.

RICHMOND, IND.—By the completion of the Dayton & Western traction line into Richmond, Indianapolis and Dayton, Ohio, are joined by a continuous line which is one of the longest in the world. It not only links Ohio and Indiana, furnishing many important connections, but it will be one part of the trunk line that will eventually connect St. Louis and New York, with branches that will touch Cincinnati, Cleveland, Toledo, Detroit and other important points.

LANCASTER, PA.—A charter has been granted to the Lancaster & Coatesville Street Railway Company with a capital stock of $150,000. The incorporators of the company are A. C. Baldwin, C. R. Herr, Adam L. Landis, John L. Leaman, R. A. Baldwin, A. H. Hostetter, Adam S. Ranck, Henry S. Rutter, Willis Rohrer, John K. Diehm, A. L. Leaman, Frank G. Groff, Moses Snavely, B. S. Weiler, J. Frank Seldomridge, J. W. Stern, I. N. Hurst and H. E. Hess. The road is to begin at Witmer's Bridge and pass through the villages of Bird-in-Hand, Intercourse, Spring Garden, White Horse, Cains, Compassville, Sandy Hill, Wagontown, thence to Coatesville.

NEWARK, OHIO—The Newark, Martinsburg & Mt. Vernon Traction Company has been organized with the following officers: President, E. H. Everett; vice-president, Dr. J. F. Shrontz; treasurer, John A. Chilcote; secretary, Frank E. Elliott. The company has secured practically the whole right of way from Newark through Martinsburg and Gambier to Mt. Vernon, and it is the intention to complete the road immediately. This road will complete a traction line from Cincinnati to Cleveland, as Cleveland is now connected with Wooster, and Newark with Cincinnati. From a point between Martinsburg and Gambier the new company will build a connecting line directly northward to Wooster, thus completing the transstate line.

FOND DU LAC, WIS.—The Fond du Lac & Oshkosh Electric Railway Company and the Fond du Lac Street Railway and Electric Light Company have been consolidated under the name of the Eastern Wisconsin Railway and Light Company, capital $500,000. This means a consolidation of the Fond du Lac Street Railway and Light Company, the gas company and the interurban line into one interest. No new line will be built from this city to Oshkosh as has been announced. The officers of the new company are: President, F. B. Hoskins, of Fond du Lac; vice-president and general manager, T. F. Grover, of Fond du Lac; secretary, B. Wild, Jr., of Fond du Lac; treasurer, W. E. Cole, of Fond du Lac; directors, F. B. Hopkins, T. F. Grover, B. Wild, Jr., W. E. Cole and E. B. Herren, of Fond du Lac, and Leander Choate and Elmer Leach, of Oshkosh.

CAMDEN, N. J.—It is stated that the long-talked of trolley line connecting Philadelphia and Atlantic City will be completed and in operation by May 1, 1905. It will be a four track electric road and work upon the construction will begin within the next thirty days. Surveys have been completed, the right of way obtained and contracts entered into for the entire work. The road will be virtually an air line. It will run direct to Clementon, eight miles from the Gloucester ferry, from whence it will parallel the Reading, keeping to the south, but within a quarter of a mile of that line, for the entire distance. The estimated cost of the construction of the road is $9,000,000. Two of the tracks will be for passenger service and two for freight. Both express and local traffic will be catered to and it is expected to make the run from Philadelphia, a distance of fifty-two miles, to Atlantic City in less than an hour. Numerous stations are to be erected and an immense power plant is to be built half way between Gloucester and Atlantic City.

NEW INCORPORATIONS.

ALBANY, N. Y.—Clinton Telephone Company. $50,000.

BAY CITY, MICH.—United Traction Company. $250,000.

LINCOLN, NEB.—The Virginia Telephone Company. $4,000.

DES MOINES, IOWA—What Cheer Telephone Company. $5,000.

DILLONVILLE, OHIO—Vigilant Telephone Company. $3,000.

CRIPPLE CREEK, COL.—La Bonte Telephone Company. $25,000.

NEWPORT, ARK.—The Farmers' Telephone Company. $100,000.

COSHOCTON, OHIO—The Citizens' Telephone Company. $50,000.

LANSING, MICH.—Alpena Light, Heat and Power Company. $500,000.

KEOKUK, IOWA—Union Telephone and Telegraph Company. $1,500,000.

DES MOINES, IOWA—The Archer-Primghar-Philby Rural Telephone Company. $1,000.

HILLSBORO, ILL.—Hillsboro Electric Light and Power Company. Increased to $25,000.

FRANKFORT, KY.—The McKee & Booneville Telephone and Telegraph Company. $3,000.

COLUMBUS, OHIO—Butler County Western Telephone Company. Increased from $5,000 to $12,000.

COLUMBUS, OHIO—The Cincinnati Telephone Company. Increased from $50,000 to $1,000,000.

ELMA, N. Y.—Elma Telephone Exchange. $5,000. Incorporators: Herman Juge, R. Peter and Herbert B. Lee.

LANSING, MICH.—South Dover Telephone Company. $1,000. Traverse Bay Telephone Company. $4,000.

GERMANTOWN, PA.—The Germantown Independent Telephone Company. Increased from $2,500 to $10,000.

JOHNSTOWN, OHIO—The Johnstown & Creton Telephone Company. Increased from $30,000 to $50,000.

SPRINGFIELD, ILL.—Pitcher Telephone Company. $7,500. Incorporators: James Bayne, W. Ford and L. D. Pitcher.

MUSKOGEE, I. T.—The Muskogee Traction Company. $300,000 Incorporators: J. L. Wisornan, W. P. Dewar, W. R. Raton and Ruel Haskell.

ASHLAND, WIS.—The Bayfield County Telephone Company $30,000. Incorporators: T. C. Jacobs, C. F. Latimer and C. S. Lamoreaux.

ST. PAUL, MINN.—Thompson Electric Company. $25,000. Incorporators: William G. Jordan, Frank B. Thompson and Ralph D. Thompson.

FRANKFORT, KY.—Hickman County Telephone Company. $5,000. Incorporators: Thomas Emerson, B. A. Boone and J. R. Scarbrough.

WINONA, MINN.—The Lewiston Telephone Company. $10,000. Incorporators: John Gaffney, Henry E. Wirt, Peter C. Daley, B. S. Blanchard, M. A. Williams.

LOS ANGELES, CAL.—The Whittier Telephone and Telegraph Company. $100,000. Directors: P. T. Spencer, W. Johnson, C. L. Zahn, Los Angeles, A. Hadley and E. W. Bacon, Whittier.

GLENWOOD, MINN.—Glenwood Mill and Electric Light Company. $25,000. Incorporators: Peter Peterson, W. F. Dougherty, M. A. Wollan, George W. Brown, J. H. McCaulay and J. R. Serrin.

CHESTER, W. VA.—The Ohio Valley Street Railway Company. $25,000. Incorporators: E. D. Marshall and John A. Gardner, of Chester, Thomas C. Pitcairn and John W. Bailey, of Pittsburg, and George W. Palmer, of New Cumberland, W. Va.

SPRINGFIELD, ILL.—The Decatur, Tuscola & Champaign Railroad Company. $50,000. Incorporators: J. H. Culver, Charles S. Hankins, William H. Black, J. M. Clokey, D. L. Campbell, J. L. Ray, Ashton Campbell, Charles G. Eckhart and A. W. Wallace.

PERSONAL MENTION.

DR. LOUIS BELL, the well-known consulting electrical engineer and electrical expert, of Boston, Mass., was a visitor to New York city last week.

MR. ROBERT SIBLEY, Berkeley, Cal., has been appointed professor of mechanical and electrical engineering at the University of Montana, at Missoula, Mont.

MR. D. M. REARDON, formerly of Flagstaff, Ariz., is now located in San Francisco, Cal., in connection with the mining interests of the General Electric Company.

MR. M. S. KETCHUM, assistant professor of civil engineering of the University of Illinois, Champaign, Ill., was married on September 17 to Miss Mary Esther Beatty, of Newton, Iowa.

MR. WILLIAM R. CORSON, consulting engineer, has removed his office to No. 724 in the Connecticut Mutual Life Insurance Company's Building, corner Main and Pearl streets, Hartford, Ct.

MR. WILLIAM R. HILL, M. Am. Soc. C. E., has tendered his resignation as head of the Aqueduct Commission of New York city, to take effect October 14. Mr. J. Waldo Smith will succeed him the following day.

MR. LEWIS G. MARTIN, the well-known cable expert of the Okonite Company, New York city, has returned from the Philippine Islands, where he was recently stationed in charge of the laying of the shore end of the Pacific cable at Manila.

MR. C. W. BARTLETT, the Nebraska representative of the Stromberg-Carlson Telephone Manufacturing Company, is now located at 1635 South Twenty-second street, Lincoln, Neb. Mr. Bartlett's previous address was Kansas City, Mo.

MR. C. C. WARREN, president of the Warren Electric Manufacturing Company, Sandusky, Ohio, stopped at New York en route to Ohio one day last week. This company's factory is especially busy at this moment in the production of alternators, most of which are of the larger units.

MR. WILLIAM H. HILL, manager of the foreign department of the General Electric Company, New York, died on the morning of September 29 at his home in Orange, N. J. Mr. Hill recently returned from a two years' stay in Mexico, where he was located in the interests of the General Electric Company.

MR. W. B. CARVELL has been appointed manager of the new electric light plant at Allensville, Ky. He has also been appointed manager of the new telephone exchange which is to be put in at Allensville by the Home Telephone Company of Tennessee. The current for the electric lights at Allensville will be taken from the electric power plant at Guthrie, Ky.

MR. C. H. BROWNELL, of Peru, Ind., manufacturer of telephone booths, was a New York visitor last week. Mr. Brownell reports that the demand for booths in the telephone field is constantly increasing, the advantages of quiet and secluded telephoning evidently growing rapidly in favor. The telephone is now considered a necessity in every modern office.

MR. BOARDMAN HALL, of Boston, Mass., representing the company of capitalists which is to build the Rockland, South Thomaston & Owls Head Street Railway, in the state of Maine, was in Rockland last week going over the survey which is being made. Mr. Hall said work on the road will be begun in the early spring and rushed so that by the time of the opening of the summer season of 1904 the road will be in operation.

MR. THOMAS E. CLARK, president and general manager, and Mr. Ackland Stiling, advertising manager, of the Thomas E. Clark Wireless Telegraph-Telephone Company, Detroit, Mich., left Thursday on a business trip to St. Louis, Mo., on matters pertaining to the company's exhibit at St. Louis Exposition. It is the intention of this company to have a most attractive exhibit, many new thoughts and features being brought before the visitors.

MR. ALEXANDER J. CASSETT, president of the Pennsylvania Railroad, has resigned from the board of directors of the Public Service Corporation of New Jersey. Mr. Cassett tendered his resignation in July, but this was not acted upon, as no meeting of the directors had been held since that time. Mr. A. H. Carleton, third vice-president of the corporation and former president of the United Electric Company, of New Jersey, has succeeded Mr. Cassett as a director.

MR. EUGENE L. ASHLEY, of Glens Falls, N. Y., president of the Hudson River Water Power Company, was given a banquet at Saratoga, N. Y., on September 24, by the citizens of Glens Falls, South Glens Falls, Sandy Hill, Fort Edward and other towns. The banquet was a testimonial in recognition of the perseverance displayed by President Ashley in successfully carrying forward the construction of the granite dam that harnesses the Hudson river at Spier's Falls, Saratoga County.

MR. L. C. VAN VESS, general manager of the Lincoln, Neb., Gas and Electric Company, has been asked by President Edgar to report to the twenty-seventh convention of the National Electric Light Association, to be held in Boston next May or June, on lost and unaccounted for current. Mr. Van Ness made a report on this subject at the Chicago meeting. He has been giving the matter considerable further study since that time, and hopes to make the next report much more valuable and interesting than any former ones.

MR. W. B. LONGYEAR has resigned his position as controller of the Brooklyn Rapid Transit Company, on account of ill health. Mr. Longyear has been ill for some time and would not risk the severe winter in New York, so has made arrangements to go to New Mexico. Mr. Howard Abel, a western man, has been chosen for the position of controller. Mr. Abel was for many years associated with Mr. Charles T. Yerkes, and was connected with the management of the North and West Chicago Street Railway companies.

SIR JOHN DICKSON-POYNDER, Bart., M. P.; Mr. George Gibb, director and general manager of the North-Eastern Railroad; Lord Ribblesdale and Sir David Barbour, K. C. M. G., members of the Royal Railroad Commission appointed to study the American street railway systems, with a view to bettering the conditions in Great Britain, and especially in London, arrived in New York on September 26 on the White Star steamship Arabic. No definite plan has been determined upon for the commission to follow out, but an investigation will be made of every branch of American street railroads. It is stated that three weeks will be spent in New York and Boston.

MR. RICHARD T. LAFFIN, for three years general manager of the Worcester Consolidated Street Railway, has resigned to accept the position of general manager of the Manila Electric Railway, Light and Power Company. Mr. Laffin's resignation will take effect on January 1, 1904, and he expects about the first of the year to depart for the Philippines to assume the duties of his new position. The company will build an electric railway system in Manila, connecting the city proper with the suburbs. It will also build an electric light station for lighting the city of Manila. The company now owns a steam road which will be converted to electric traction, and will build and equip valuable water power systems, the rights for which it already owns.

MR. F. A. STRATTON, vice-president of the Westchester Lighting Company, of New York, was tendered a complimentary dinner by a number of prominent citizens on Saturday evening, September 26. Mr. Stratton is one of the most popular railway men in the East. During the international yacht races he gave a delightful outing to a hundred or more gentlemen friends, in the form of an ocean trip on the steamer Isabella, which he chartered for the occasion. Among those in the party were many who had been Mr. Stratton's guests on former occasions, and the idea was suggested that some substantial recognition be made of his good fellowship and generous hospitality. Subsequently, Mr. William Archer, of Mount Vernon; Mr. John H. Bangs, of New Rochelle, and Mr. Frank Hardy, of Larchmont, were appointed a committee to make the necessary arrangements. The dinner was served in the large dining-room of the Hunters Island Inn, on Pelham road. A souvenir menu was prepared, containing on the front cover a reproduction of the burgee of Sir Thomas Lipton and Mr. Stratton, and on the inside front page a splendid likeness of Mr. Stratton. Speeches were made by Mayor Henry Clark, of New Rochelle; Mayor Edwin W. Fiske, of Mount Vernon; Mayor Michael J. Walsh, of Yonkers; Mr. Frank Millard, Mr. Stephen Van Tassel, Coroner Russell, of Tarrytown; Dr. James H. Brennan, of New Rochelle; Mr. Comely, president of the village of Port Chester, and others.

INDUSTRIAL ITEMS.

THE CANADIAN GENERAL ELECTRIC COMPANY, Limited, Toronto, Canada, is now representing the Electric Storage Battery Company, in the sales of the chloride accumulator and the "Exide" accumulator throughout Canada.

J. H. BUNNELL & COMPANY, New York city, N. Y., is sending out an attractive circular descriptive of the "Beekophone." The instrument is well constructed, with solid back transmitter, double pole receiver, vibrator bell and call button.

THE STANDARD UNDERGROUND CABLE COMPANY, Pittsburg, Pa., announces the removal of its San Francisco office from the Mills Building to more commodious quarters in the Crossley Building, at Mission and New Montgomery streets.

THE WYCKOFF PIPE AND CREOSOTING COMPANY, Stamford, Ct., has issued a pamphlet descriptive of creosoted conduits for underground wires and cables, poles and cross-arms, railroad ties, bridge timber, piles, paving blocks, fence posts and lumber.

THE THOMAS E. CLARK WIRELESS TELEGRAPH-TELEPHONE COMPANY, Detroit, Mich., announces that the McCoy Engineering Company, 107 East German street, Baltimore, Md., and 23 Corcoran Building, Washington, D. C., is its eastern representative.

THE ROPE FIBRE PULLEY COVERING COMPANY, Springfield, Ohio, which a few months ago placed on the market a new adaption for facilitating power transmission, as its name would indicate, advises that it has made rapid progress in the marketing of the new invention.

THE STANLEY ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., announces the opening of two new sales offices, one at Cincinnati, Ohio, with headquarters in the Perin Building, in charge of Mr. O. H. P. Fant, and the other in the Century Building, St. Louis, Mo., in charge of Mr. F. Johnson.

THE INTERNATIONAL STEAM ENGINEERING COMPANY, Atlanta, Ga., states that its cooling tower business is assuming large proportions. The company has recently closed a contract for a 3,000-horse-power cooling tower, with other propositions under way for apparatus up to 10,000-horse-power capacity.

THE LOS ANGELES RAILWAY COMPANY and Pacific Electric Railway Company, Los Angeles, Cal., has each placed an order with the Electric Storage Battery Company for a sufficient number of plates to increase the capacity of its respective batteries 100 per cent. Each battery will now have a capacity of 2,000 amperes for one hour.

THE NATIONAL CARBON COMPANY, Cleveland, Ohio, through its sales manager, Mr. N. C. Cotabish, reports the heaviest demand for carbon products ever known at this season of the year. The large factories at Cleveland and the company's subfactories in different parts of the country are running at practically the fullest capacity.

THE PITTSBURG BLUE-PRINT COMPANY, Pittsburg, Pa., will be pleased to mail an illustrated catalogue describing its electric blue-printing apparatus. Several types are described, including the upright wall machine and the tilting wall machine, both automatic and non-automatic. This company also makes blue-print wringers and other specialties of this nature.

THE SPRAGUE ELECTRIC COMPANY, New York city, in its bulletin No. 411, gives a complete description and illustrations of iron-armored conduit, junction boxes, fittings, tools, etc. This bulletin illustrates a very complete line of equipment of this nature and will be found of great practical value to any one having need of such material. The bulletin will be sent upon request.

THE ELECTRIC APPLIANCE COMPANY, Chicago, Ill., announces it will be pleased to send the trade, by prepaid express, upon receipt of application, its new catalogue. Applications will receive prompt attention, provided they are accompanied by business cards. These catalogues are of the latest type and are very comprehensive.

THE UNITED TELPHERAGE COMPANY, Westfield, N. J., is sending out two very attractive circulars, being No. 39 and No. 40. No. 39 treats of the electrical handling of miscellaneous freight and No. 40 treats of the handling of reserve storage, coal, coke and ashes. Circulars will undoubtedly be interesting to those interested in telpherage and will be sent on request.

THE MICA INSULATOR COMPANY, New York city, is mailing an attractive postal card bearing the title of "Let Well Enough Alone if You Are Unprogressive and 'Well Enough' Is Good Enough." The Mica Insulator Company is the manufacturer of a high-grade insulating compound for armatures, field coils, magnets, etc. This is claimed to be moisture-proof, durable, elastic and non-corrosive. The company will be pleased to send samples and descriptive booklet on request.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Rochester, N. Y., and Chicago, Ill., has recently issued a very attractive catalogue which includes bulletins Nos. 6 and 7. This catalogue is fully up to the standard in completeness and design. Bulletin No. 6 treats of generator call switchboards, and embodies a very good feature in that it shows on the page opposite to the half-tone engraving of the cabinets a drawing of the same. Bulletin No. 7 treats of a generator call switchboard and parts. Net prices are therein quoted on all switchboard parts. Included in the catalogue is a summary sheet which will be found in the book. This catalogue will be sent on request.

THE NORTH ELECTRIC COMPANY, Cleveland, Ohio, is to be congratulated upon a recent publication which has been compiled and designed by its advertising department, under the direction of Mr. Frank F. Sapp. The work is entitled "The Rural Telephone." On the cover, which is a handsome rag effect in a slate black, is mounted a photographic reproduction of a rural telephone line which is highly artistic in effect. The illustrations are beautifully worked out and the processing which the paper has received after the printing has greatly enhanced the finish of the work. The reading matter is carefully arranged and of great practical value to any one interested in the rural telephone. The booklet comes in a handsome envelope made of the same quality of paper as the cover of the booklet. The whole is no doubt one of the handsomest catalogues ever produced.

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y., has just brought out a very attractive booklet, "Permanency of Transformer Insulation." It is the object of this booklet to describe how the company has developed a process to accomplish the necessary results in transformer insulation, which are not only invaluable, but necessary to a good transformer. The book will be found profitable to those who are interested in transformers, and will be sent on request. The company has also brought out a handsome booklet descriptive of its core type transformers. In this booklet it states it began the manufacture of this type of transformer in 1896, and since that time continued improvements have been made in all the features that go to make up a good transformer. Some of these features have been described therein. This booklet will also, undoubtedly, prove valuable to those interested in transformers, and will be sent on request.

THE H. W. JOHNS-MANVILLE COMPANY, 100 William street, New York city, has secured a large order for roofing from the War Department, to be used on the army buildings in the Philippine Islands. A total of 14,020 rolls of roofing, making over 900 tons, has been ordered. This is enough to cover over sixty-five acres, or will make a strip a yard wide and about 200 miles long. Ten bids were submitted, and the award was made after a careful investigation by the War Department and the supervising architect of the Treasury. Prompt delivery of the roofing was essential, and it is of interest to note that one order for 11,120 rolls was completed within thirty days, and another for 2,900 rolls within ten days after receipt. The company has just issued a unique folder, "Pictorial Prologue and Pictorial Epilogue." Pictorial Prologue shows a picture of Uncle Sam receiving bids for 11,120 rolls of roofing paper April 30, 1903, and for 2,900 rolls July 7, 1903, each to contain 216 square feet. Pictorial Epilogue shows copy of report made July 23, 1903, by the supervising architect at Washington, D. C. The company's Pittsburg branch on account of increased business has found it necessary to secure larger quarters. It now occupies the entire building at 218-220 First street, Pittsburg, Pa.